PR 29-82

TECHNICAL DATA
AAP MISSION 1A 60-DAY STUDY

Contract NAS 8-21004
20 September 1967

Approved For Release 2002/09/03 : CIA-RDP70B00584R000200060001-6

MARTIN MARIETTA CORPORATION
DENVER DIVISION

FOREWORD

This document presents detailed technical data that was generated during the AAP Mission 1A 60-Day Study that will provide clarification and support for the Final Report, PR 29-81.

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1. INTRODUCTION

1.1 Purpose and Scope

This technical report presents a description of the work completed and the results obtained during a two-month study conducted by the Martin Marietta Corporation (MMC) for the National Aeronautics and Space Administration, Manned Spacecraft Center (NASA-MSC). The purpose of the study was to define a hardware configuration and to develop an approach for integrating twenty-three NASA designated experiments into AAP Mission 1A (AAP-1A) to be flown in late 1968 or early 1969. The objectives of the experiment complement and mission operations are:

- To perform an early evaluation of the operational feasibility of selected earth-resources, bioscientific, meteorology and astronomy experiments.
- To verify the enhancement of experiments by the presence of man for monitoring, controlling and interpreting data obtained on orbit.
- To obtain operating experience on available hardware.
- To extend experiment coverage to 50 degrees latitude.

The study, concluded September 5, 1967, was closely coordinated with NASA-MSC and incorporates information obtained from visits to North American Aviation, Inc., (NAA) and from various sources within NASA.

The major tasks accomplished during the study period are:

- Definition of experiment requirements and availability through communication and personal contact with each of the NASA-MSC experiment development managers, appropriate principal investigators and experiments contractors.
- Preparation of preliminary mission timelines, supporting criteria, and crew integration criteria.

1.1 (Continued)

- Preparation of trade studies and analyses to determine the optimum method of satisfying experiment and subsystem support requirements.

- Definition of hardware configurations developed from trade studies and analyses conducted within established ground rules.

- Development of approaches to procure, manufacture, integrate, test and operate the experiments, supporting structure, and subsystems.

- Coordination of study activities with NASA-MSC and preliminary evaluation of interfaces with the Command Service Module (CSM) and KSC operations.

1.2 Summary - The results of the study described by this report show that the mission objectives can be met.

The schedule for the January 1969 launch is shown in Figure 1.2-1. The milestones to accomplish a January 1969 flight require that:

- Phase D initiated, 11/1/67

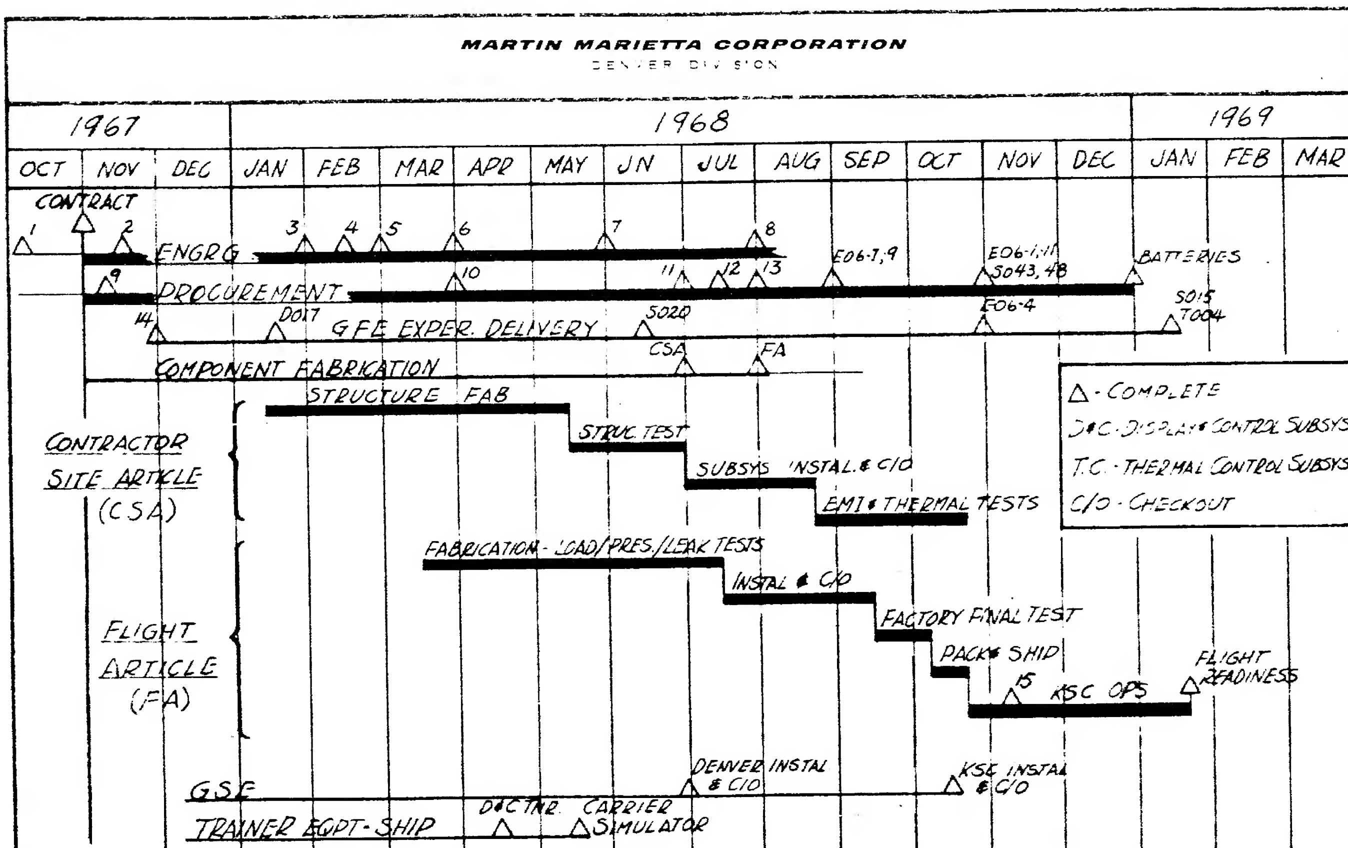
- Flight article engineering completed, 8/1/68

- Flight article assembled, 9/15/68

- Denver testing completed, 10/5/68

- Flight article shipped 10/20/68

It is feasible to meet a January, 1969 launch date with special considerations such as a three-month KSC operation overlapping test article qualification testing with flight article acceptance testing, and removal of four late delivery experiments from the grouping. An April, 1969 launch date permits all of the experiments to be flown with a reduction in the amount of premium time necessary.



1 LONG LEAD PROCUREMENT RELEASE	6 ASSEMBLY & INSTAL. DESIGN RELEASE	11 STRUCTURE PROCUREMENT
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3 DATA SUBSYS. DESIGN RELEASE	8 FLIGHT ARTICLE DESIGN RELEASE	13 DATA SUBSYS PROCUREMENT
4 STRUC. & T.C. DESIGN RELEASE	9 LONG LEAD PROCUR ORDERS PLACED	14 D008 & 9; T002, 3; S0.6 17, 18, 19
5 D&C DESIGN RELEASE	10 D&C AND POWER PROCUREMENT	15 ALL EXPER INSTALLED EXCEPT S015 & T004

Figure 1.2-1, AAP-1A Phase D Schedule

1.2 (Continued)

To meet the projected schedule, maximum use will be made of:

- An integrated project team with minimum communication problems.
- Use of personnel having experience on similar earth orbit programs, having shortened schedules from go-ahead to launch.
- Applying existing procurement expediting techniques to critical hardware.
- Conducting incremental design reviews so that corrections can be incorporated on a timely basis, minimizing total program impact.
- Making incremental inspections to avoid costly and time consuming effects on manufacturing.

An AAP-1A baseline mission, developed with NASA-MSC coordination, identifies an average of 6 day-time passes over the Continental United States each 24 hours at 140-150 nautical mile altitude and 50° inclination. Launch at 1000 EST April 1, 1969 optimizes day time coverage of the Continental United States and permits day time recovery in the primary Atlantic recovery area at the conclusion of a 14-day or a 15-day mission.

The spacecraft orientation found to provide the best balance of crew visibility, carrier weight, orbital decay, sensor contamination, RCS propellant usage and disturbing torque considerations was found to be earth vertical (nose down), with the crew in a heads forward couch position.

Operational timelines developed during the study identify the feasibility for recovery of 100% of the requested data for 15 of the experiments with reduced return for the remaining experiments. Limiting factors are available crew time, available RCS propellant and data dump.

1.2 (Continued)

Carrier crew position and required carrier entries to support experiment activities are compatible with operational timelines and hardware capabilities of the recommended carrier configuration. A total of ten entries into the pressurized carrier are required to operate experiments, utilizing the dome and side mounted airlocks and changing film of the internally mounted cameras. Return stowage volume and weight requirements are within CSM capabilities.

The recommended carrier configuration (Figure 1.2-2) consists of a welded aluminum cone enclosure 84" in diameter at the experiment mounting end and 110" in overall length. The enclosed volume is pressurized to 5 psia with oxygen during crew habitation. Scientific airlocks are provided in the cone side and dome. A bolted dome is provided for prelaunch interior access. A truss, which supports the cone in the SLA at the LM hard points, provides the structural support for all experiments not requiring inflight access or pressurization and support for subsystems required by the experiments. The truss also provides the lateral stiffness required by the SLA. The carrier interface with the CSM utilizes LM docking hardware.

Carrier-mounted experiments are provided power from five silver zinc batteries arranged to provide redundancy to two primary power buses. Two additional batteries provide redundant power for EMI sensitive experiments. Redundant inverters supply 400 cycle AC for experiment and subsystem use. Total capacity of the power system is 78.4 KWH of 28 volt DC and 115V, 400 cycle, three phase power.

A data management system employing one S-band and three VHF transmitters provides for the handling of experiment data and subsystem housekeeping data. The data system includes its own time generating system, a tape recorder and PCM encoder and utilizes the frog otolith and X-ray astronomy experiment data equipment.

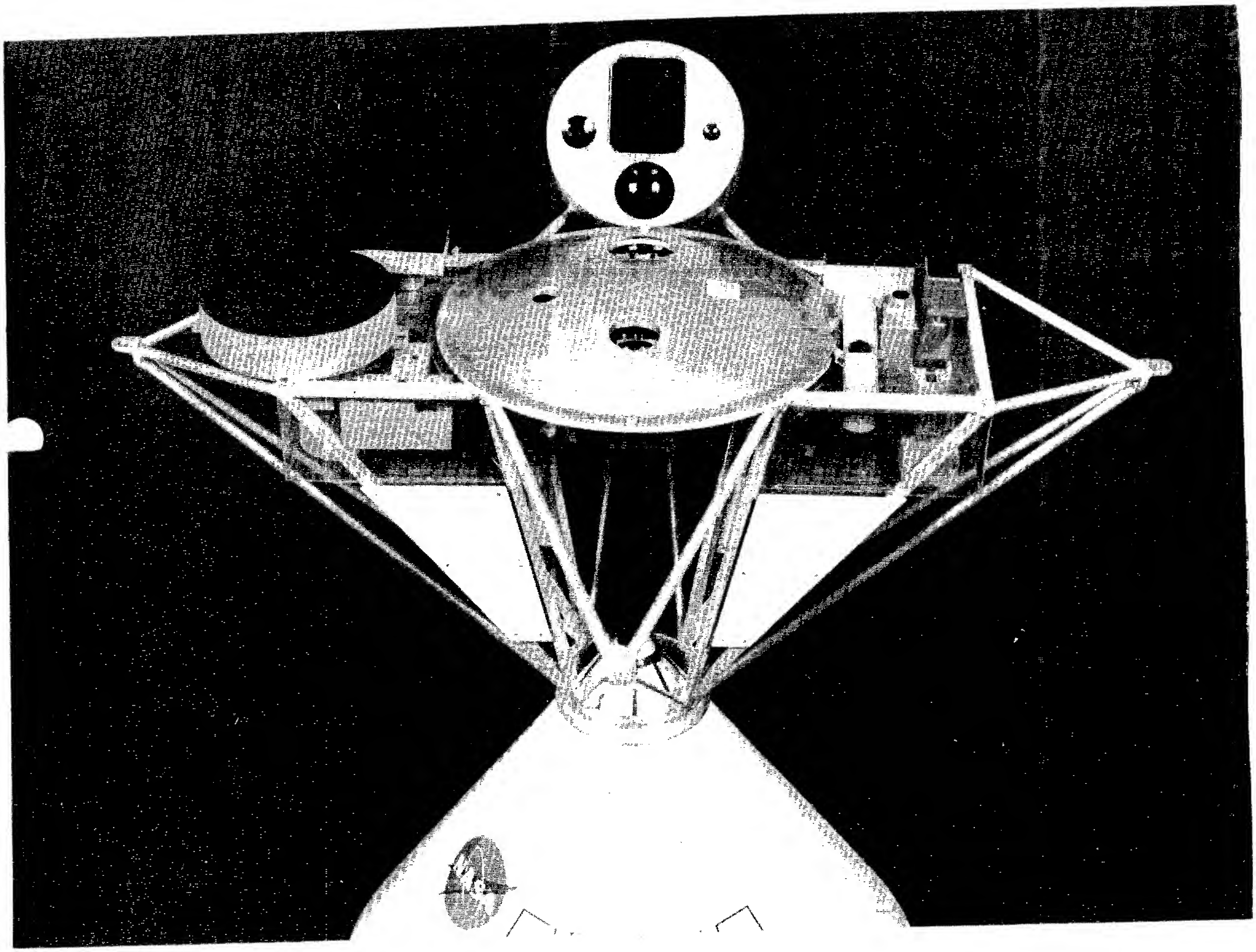


Figure 1.2-2, AAP-1A Carrier Configuration

1.2 (Continued)

An active/passive thermal control system using Freon 21 coolant and a truss-mounted series radiator in combination with multilayer insulation provides experiment and subsystem temperature control. The active system is redundant, having a heat rejection radiator capacity of 256 BTU/hr minimum to 1300 BTU/hr maximum time average heat load.

The G&N system in the CSM provides the prime mode for attitude control to orient the experiments to the local vertical. Manual control is used for solar pointing. A combination of the G&N system and manual control is used for stellar orientation. A backup system is provided for local vertical control, consisting of a horizon scanner-gyrocompass attitude reference system to drive a display for manual control.

Modifications to the CSM have been minimized by providing independent carrier subsystems to support experiment requirements. These changes include installation of display and control panels (2) and wiring harnesses to existing docking ring connectors, extension of the pressure suit umbilical and return weight and volume stowage provisions.

A display and control system provides a portable panel, boosted in the carrier, and operated in the CM. A keyboard call-up system on the panel interfaces with the carrier-mounted control logic to minimize CSM/carrier interfaces.

A ground operations plan, developed during the study, includes an acceptance flow, a GSE functional matrix, and a preliminary listing of GSE end items. Automatic checkout, using a GFP digital test set (DTS) and existing Denver and KSC ground stations, is used. A modified inner SLA access platform set uses attachment hard points within the SLA.

Crew safety is maximized through the use of redundant systems; use of factors of safety compatible with manned systems; use of flight proven hardware where possible; and the selection of

1.2 (Continued)

materials, design, and installation techniques that provide minimum crewman risk.

Wherever possible, carrier system components are selected from comparable systems flown on the Gemini and Apollo programs where significant flight and ground test history is logged. Of the total number of individual components to be used on the carrier (exclusing experiments and structure) approximately 91 percent have had previous performance history on NASA or Air Force programs in flight and/or ground tests.

The carrier design provides sufficient growth capability and flexibility in terms of a modular design approach to permit changes in experiments within the limits of weight and mission constraints. Truss-mounted racks for mounting subsystems and experiments allows not only ease in on-pad accessibility, but also facilitates component or experiment changes with minimum effect on the overall configuration.

1.3 Constraints

1.3.1 The program objectives must be attained within basic limitations, which have become program constraints. These are:

- Provide for an early launch - January, 1969 desired
- Use a single, uprated Saturn IB booster
- Use the basic Block II Command-Service Module (CSM) with minimal change
- Insure crew safety
- Minimize cost
- Provide for a mission which is open-ended to 14 days.

1.3.2 Analysis of each program objective and constraint results in identification of additional guide lines. These ground rules are those used in conducting this study and are not inflexible, should program demands require revisions.

1.3.2.1 The program objectives result in:

- Selection of compatible available experiments.
- A 140-150 n.m. altitude earth orbit at 50^{o} inclination.
- Time in orbit compatible with providing useful experiment data.
- Launch time and date optimized for experimentation results.
- Use of the 1968 Apollo Manned Spaceflight Network (MSFN) without augmentation.
- Recovery of the maximum amount of useable data.
- No orbital make-up or plane changes required.

1.3.2.2 The early launch date results in:

- Selection of experiments and design of subsystems for which hardware can be available.
- Use of existing hardware where possible, with little or no change.

1.3.2.3 Reaching the desired orbit with 2 Saturn 1B results in:

- The weight of the experiments, carrier, and subsystems not to exceed the performance capability of the Saturn 1B. The target weight is set at 5000 pounds.
- Adherence to LM/SLA mounting and withdrawal constraints.
- SLA lateral support to be provided by the carrier mounting truss.
- No resupply in orbit.

1.3.2.4 Use of the basic Block II CSM results in:

- Minimal CSM modifications and simple interface.
- Use of LM/CSM design docking hardware.
- A limitation of 281 pounds of Reaction Control System (RCS) propellant available for carrier use.

1.3.2.5 Crew safety considerations require:

- No single malfunction to affect crew safety.
- All hardware and design to conform to new flamability requirements.
- EVA to be avoided.

1.3.2.6 Cost considerations require:

- Selection of experiments, subsystem hardware and operations which take maximum advantage of past experience and testing.

1.3.2.6 (Continued)

- Efficient application of existing technical resources and facilities.

1.3.3 Additional guidelines, based on NASA-MSC direction, previous experience on similar programs and good engineering practice were developed for systems and each of the subsystem design disciplines involved.

1.3.3.1 Systems:

- Wherever possible, carrier subsystems and experiments are inactive during boost.
- All carrier/subsystem designs provide for ground test and checkout independent from that of the CSM insofar as possible.
- Experiments and support subsystems are to be accessible on the ground for maintenance any time prior to inner SLA access platform set withdrawal.
- Electromagnetic interference control and susceptibility is to be considered in the basic design of all electrical and electronic components and interconnecting wiring.
- No sharing of ground returns between signal, power and control circuits shall exist.
- Subsystems and experiments will be designed so that an experiment failure does not affect operation on the basic subsystem.
- Subsystems are designed to minimize failure mode propagation across their interfaces with other equipment.
- There are no provisions for inflight maintenance.

1.3.3.2 Structures:

- Presently designed LM/SLA support structure and separation hardware are used.

1.3.3.2 (Continued)

- The carrier c.g. is to be located within a three foot radius sphere centered between the SLA support points.

1.3.3.3 Thermal Control:

- Design is for 100% duty cycle for 14-day mission.
- The primary mode of thermal control for the carrier is to be passive conduction and radiation to deep space.
- Thermal control for the carrier is to be an active closed loop pump/radiator system in combination with passive devices such as insulation and conduction to structural heat sinks.

1.3.3.4 Display and Control

- Design is for 100% duty cycle for a 14-day mission.
- D&C panel is to be compatible with suited and unsuited single crewman operation.
- No carrier equipment or subsystem displays are to be located on existing CM panels.

1.3.3.5 Electrical Power and Distribution:

- Design for 100% duty cycle for a 14-day mission.
- Carrier, CSM and GSE to incorporate a single point ground concept.
- Connections between carrier and CSM are not to interfere with thermal pressure hatch opening or closing or the emergency isolation and/or separation from the carrier.
- All power sources are to be redundant with isolation provided between parallel power sources.

1.3.3.6 Data Management:

- Ground commands for data dump are provided by CM uplink.

- Capability to voice annotate recorded and transmitted data is to be provided.

- The data system provides real time and delayed R.F. transmission of experiment and subsystem signals.

1.3.3.7 Crew Equipment:

- A crew tether harness and illumination is required at all task locations in the carrier. Life support requirements and equipment, including oxygen, water, food, personal hygiene and waste managment equipment are supplied in the CM.

- The carrier to provide working space for one suited crewman.

1.3.3.8 Ground Operations:

- Existing Apollo GSE will be used wherever possible.

- Use of commercial equipment is acceptable for non-mission-essential operations.

- Be compatible with existing GSE, facilities, and ground operations.

- Carrier/experiment ground operations will not impact on mainline Apollo operations.

1.3.3.9 Flight Operations:

- Shirt sleeve is the preferred mode of operation in the carrier.

- Soft-suited crewman is a baseline for carrier operations because of the use of the NAA scientific airlocks there.

1.3.3.9 (Continued)

- Crewmen in the carrier are to wear Apollo A7L suits, pressurized to the CM atmosphere (5.0 psia).
- CM and carrier environment compatible with shirt-sleeved or unpressurized environment.
- During crew operations within the carrier, the CM forward hatch is to be open.
- An eight hour simultaneous sleep cycle is a goal in timeline planning.

1.3.3.10 Testing

- Piece part selection and testing determined on the basis of individual component criticality analyses.
- Maximum use of previously qualified hardware.
- Test duplication shall be minimized.
- Systems testing conducted at the highest hardware level.
- Systems verification testing limited in type and duration to provide adequate confidence that the system will perform its intended function.

2. EXPERIMENT INTEGRATION

Reference Figure 2.0-1, AAP-1A Experiment Locations

2.1 Summary

The major effort during this period consisted of the review of experiment requirements and the presentation of these requirements in a standard format for analysis by system and subsystem designers. Five groupings of experiments were considered with the final group being chosen only after the mid-term review on 9 August 1967. This final grouping includes eleven early versions of Applications A and B (Apps. A & B) experiments and twelve scientific experiments supplied from the Apollo program. Two of the Applications A and all the Application B experiments, except the Multispectral Cameras, are to be considered for Contractor supply. All other experiments are GFP. This grouping was frozen by NASA and no evaluation of alternate groupings was to be undertaken by MMC.

To establish the configurations and availability for the early Apps. A & B experiments, possible vendors were visited during July, person-to-person contact was established with MSC experiment managers, and NASA centers were either visited or contacted by phone.

The Apollo experiment data was obtained from previous studies done by MMC in support of MSC and MSFC and from a series of meetings held in Denver on August 15 and 16, where MSC personnel provided data and briefings on each of these experiments. All data were then compiled in the standard format and published in PR29-83, Compilation of Trade Studies, Engineering Analyses, and Other Reports, as Report PR29-51, Experiment Requirements.

The next step required to convert the experiment data to useful design criteria was to prepare preliminary timelines for experiment usage during the mission, to coordinate crew activities with experiment operation, and to verify that the accumulated telemetry data could be transmitted to ground stations. While these timelines were used to design the power and thermal control subsystems, a check of the RCS propellant needed for maneuvering showed excessive usage and the timelines were modified accordingly.

The scientific experiments required a slightly different approach than the applications experiments since; (1) they presently exist in storage and (2) they were designed to be installed in a

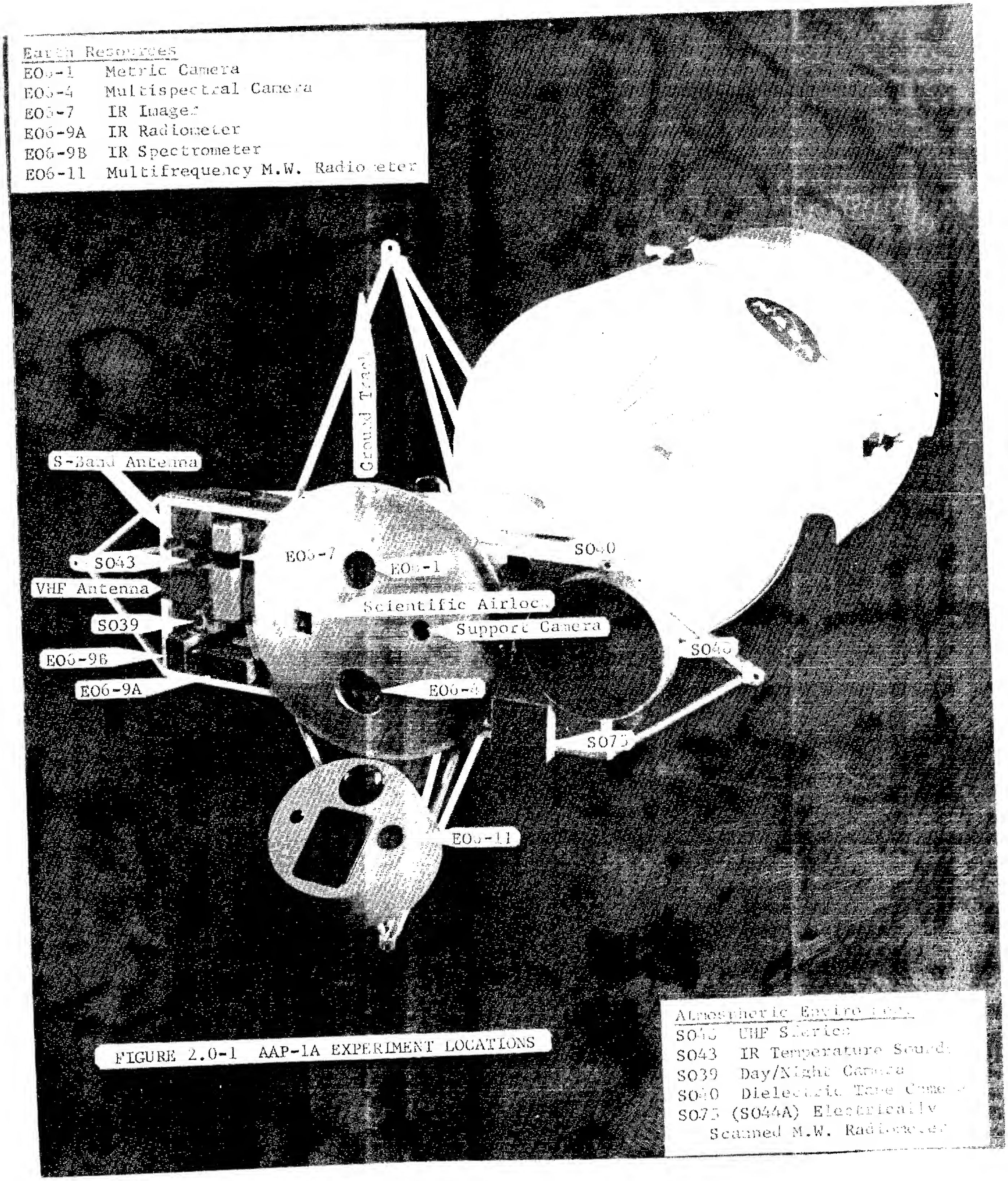


FIGURE 2.0-1 AAP-1A EXPERIMENT LOCATIONS

Block I CSM. Additional studies were, therefore, necessary to decide where to locate each experimental package, where to locate the scientific airlock units, and what modifications were necessary to the experiments to adapt them to the AAP-1A configuration. A further study was made of opening certain experiments (S019 and 20) and only bringing back the exposed film rather than the complete experiment.

A final step was to check the integrated package for the degree to which the individual experiment requirements had been satisfied.

2.2 Experiment Requirements

The Apps A & B experiments and the science experiments developed for other Apollo missions were analyzed for the fly-early AAP-1A mission. Experiments were analyzed based on priority of scientific data, schedule/availability, and requirements imposed on airborne and ground support systems. Requirements for the experiments are compiled in standard format data packages which are included in PR29-83 as Report PR29-51. The data packages, including requirements in terms of weight, volume, power, thermal control, operating time, crew operations, data and ground support equipment requirements, are summarized in Table 2.2-I, and form the basis for much of the carrier design described in this report. Some outstanding experiment requirements are discussed below.

To avoid EVA activities, all film cassettes must be mounted in an area accessible to the crew. This requires either camera mounting inside the carrier, or film chute penetrations through the pressure shell. Viewing ports, of optical quality glass, are required for internally mounted cameras. Multispectral cameras require two film cassette changes during the mission to obtain the required 540 frames/camera. The IR imager, though it images on film, cannot view through a window. Therefore, a film chute is required from the externally mounted imager to a film magazine in the carrier.

The day-night and dielectric tape camera require wide band-width data transmission channels. Playback of the experiment tape recorders requires 6.7 and 7.5 minutes for the day-night and dielectric tape cameras, respectively during each transmission to a ground station.

Many experiments are located and operated in the carrier, requiring crew operation station provisions. Two airlocks are

TABLE 2.2-I EXPERIMENT REQUIREMENTS

	PHYSICAL PARAMETERS				ELECTRICAL REQUIREMENTS			THERMAL CONSTRAINTS		CREW REQMTS	DATA REQUIREMENTS			POINTING				
	Weight (lb)	Vol (In^3)	Return Wt.(lb)	F.O.V.	Voltage (v.d.c.)	Ave.Power (Watts)	KWH*	Range (°C)	Stability (°C)	Man Hrs	Channel	Format	Freq Resp/ Bit Rate	Type	Maximum Deviation	Attitude Hold Time (Hrs)	RCS*** Reqmt (lb)	Remarks
S039 Day/Night Camera	61.0	2454	0	120°	-24.5 ±5	43	0.941	+5 to +45	N/C	4.0	1 1 25	Video Video Digital (8 bit)	140-240 KHZ 50 KHZ 8 Bps	Local Vert.	± 10°	46		Require S-Band transmitter for data handling which adds 40 lbs and $1,600,000. Cannot playback S039 and S040 data simultaneously. CRT required for S039.
S040 Dielectric Tape Camera	83.0	3168	0	98.1°	-24.5 ±5	27	0.438	+5 to +45	N/C	1.0	1 35	Video Analog	680 KHZ 8 Bps	Local Vert.	±10°	23		
S043 IR Temperature Sounder	45.0	3121	0	12°	+28 ±10	85		-30 to +30	±5	10.0	1 1	Digital (10 bit) Digital (8 bit)	100 Bps 80 Bps	Local Vert.	±5°	8.3		
S044A Electrically Scanned Microwave Radiometer	20.0	2570	0	100°	+28 ±5	20	3.965	-10 to +65	N/C	0.5	1 1	Digital (10 bit) Analog	50 Bps 50 Bps	Local Vert.	±5°	46		Temperature gradient across antenna face critical.
S048 UHF Sferics	31.0	16,941	0	126°	+28 ±1	6		0 to +60	±5	4.0	2 8	Digital (8 bit) Analog	160 Bps 8 Bps	Local Vert.	±5°	264	44	Requested 11 days continuous operation.
E06-1 Metric Camera	200.0	7540	20.0	74°	+28 ±5	250		0 to +32	±5	6.0	11	Analog	8 Bps	Local Vert.	±1.5°	6		Temperature gradient across lens critical.
E06-4 Multispectral Camera	55.0	1910	24.0	36°	Self Contained			0 to +32	±10	6.0	None	Film only	--	Local Vert.	±1.5°	5		Self contained power, two film cassette changes.
E06-7 IR Imager	120.0	4644	5.0	120°	+28 ±5 115 v.a.c. 400 Hz	150	3.907	+2 to +35	±10	1.0	4	Analog	8 Bps	Local Vert.	±1.5°	5		Only experiment requiring 400 Hz. Experiment mounted outside with film feed into carrier thru film chute.
E06-9A IR Radiometer	30.0	1771	0	0.4°	+28 ±5	60		-10 to +40	±10	1.0	1 5	Digital (10 Bit) Analog	1900 Bps 4 Bps	Local Vert.	±1.5°	5		High bit rate (10 bit 1900 SPS and experiment data output analog requiring encoding.
E06-9B Spectrometer	50.0	4800	0	0.4°	+28 ±5	40		-10 to +40	±10	1.0	1 5	Digital (10 Bit) Analog	1900 Bps 4 Bps	Local Vert.	±1.5°	5		High bit rate (10 bit 1900 SPS) and experiment data output analog requiring encoding.
E06-11 Multifrequency Microwave Radiometer	50.0	44,208	0	20°	+28 ±5	100		0 to +50	±10	0.1	1	Digital (10 Bit) Analog	50 Bps 8 Bps	Local Vert.	±1.5°	5		Largest experiment envelope
Subtotal	745.0		49.0				9.251										44	

TABLE 2.2-I EXPERIMENT REQUIREMENTS (continued)

	PHYSICAL PARAMETERS				ELECTRICAL REQUIREMENTS			THERMAL CONSTRAINTS		CREW REQMTS	DATA REQUIREMENTS			POINTING				Remarks
	Weight (lb)	Vol (In^3)	Return Wt.(lb)	F.O.V.	Voltage (v.d.c.)	Ave.Power (Watts)	KWH*	Range (°C)	Stability (°C)	Man Hrs	Channel	Format	Freq Resp/ Bit Rate	Type	Maximum Deviation	Attitude Hold Time (Hrs)	RCS*** Reqmt (lb)	
T002 Manual Navigation Sightings	6.5	395	6.5	25°	Self Contained		---	TBD	N/C	20	1	Bi-Level	5 SPS	Star Fields	±5°	20	20	Self Contained Power.
T003 Aerosol Particle Analyzer	5.5	155	5.5	None	Self Contained		---	+5 to +25	N/C	5.5	None	-	-	None	-	-	0	Self Contained Power.
T004 Frog Otolith Function	86.0	4710	0	None	+28 ±5	20	0.563	ambient	N/C	5.5	See Remarks			None	-	-	0	Requires ground control during sleep cycle, uses S017 Data System.
D008 Radiation Monitors	5.0	170	5.0	None	+27.5±2.5	0.25	0.09**	45 max	N/C	2.4	2	Analog	8 Bps	None	-	-	0	Uses CM Power and 2 Channels of CM Data Handling.
D009 Simple Navigation	12.0	451	0.5	14°	Self Contained		---	ambient	N/C	10.0	None	-	-	Star Fields& Horizons	±5°	10	36	Self Contained Power. Return Experiment Log Book.
D017 CO_2 Reduction	32.0	1758	0	None	+28 ±2	210	1,320	ambient	N/C	6.0	12	Analog	8 Bps	None	-	-	0	
S015 Zero-G Human Cell	22.0	800	22.0	None	+27.5±2.5	23	2.5 **	+20 to 35	N/C	8.2	None	-	-	None	-	-	0	Uses CM Power.
S016 Trapped Particle Asymmetry	8.0	275	8.0	210°	None Required		0	55 max	N/C	10.0	None	-	-	45° from local vertical	±2°	10	76	Requires use of A/L and Accurate S/C Orientation. Requires Non-Concurrent Sleep Cycle.
S017 X-Ray Astronomy	222.0	7305	0	20°	+27.5±2.5	134	0.342	-20 to +65	N/C	10.0	See Remarks			Star Fields	±0.5° (manual)	10	45	Requires 70 Lbs for Data System and 26 lbs for Display & Control.
S018 Micrometeorite Collection	6.0	98	6.0	180°	None Required		0	+5 to +30	N/C	2.0	None	-	-	None	-	-	0	Requires use of A/L and no RCS or waste dump during operation.
S019 UV Stellar Astronomy	43.0	1060	43.0	5°	Self Contained		---	+10 to +25	N/C	14.0	None	-	-	Star	±2°	7.0	33	Self Contained Power, requires A/L and Operator Station in Carrier.
S020 UV X-Ray Solar	25.0	600	25.0	14°	+27.5±2.5		0.032	0 to +50	N/C	15.0	3	Bi-level	1 SPS	Sun	±0.25° (manual)	4.0	16	Requires use of A/L Operator Station in Carrier.
Subtotal	473.0		121.5				2.257										226	
Total of Sheets 1 and 2	1218.0		170.5				11.508										270	

*KWH Requirement Only Reflects Scheduled Time as per Figure 2.3-1 and 2.3-2.
**Not Included in Totals. Power for these experiments provided by the Command Module.
***RCS Requirement only reflects scheduled time as per Figures 2.3-1 and 2.3-2.

required to permit simultaneous operation of several experiments, and to allow proper field of view and orientation of the experiments. Shortened crew time and fewer carrier entries by the crew are possible with the use of two airlocks.

Several of the experiments, notably the frog otolith and the trapped particle asymmetry, require operation continuously for portions of the mission, affecting crew sleep cycles. The frog otolith experiment requires operation every 30 minutes for the first three hours, hourly during the remainder of the first day, and every two to three hours thereafter for the first four mission days. The trapped particle asymmetry experiment requires operation during approximately 80% of the spacecraft passes through the South Atlantic Anomaly. A number of these passes occur during sleep periods (as shown in Figure 2.3-1).

2.3 Experiment Timelines and Utilization

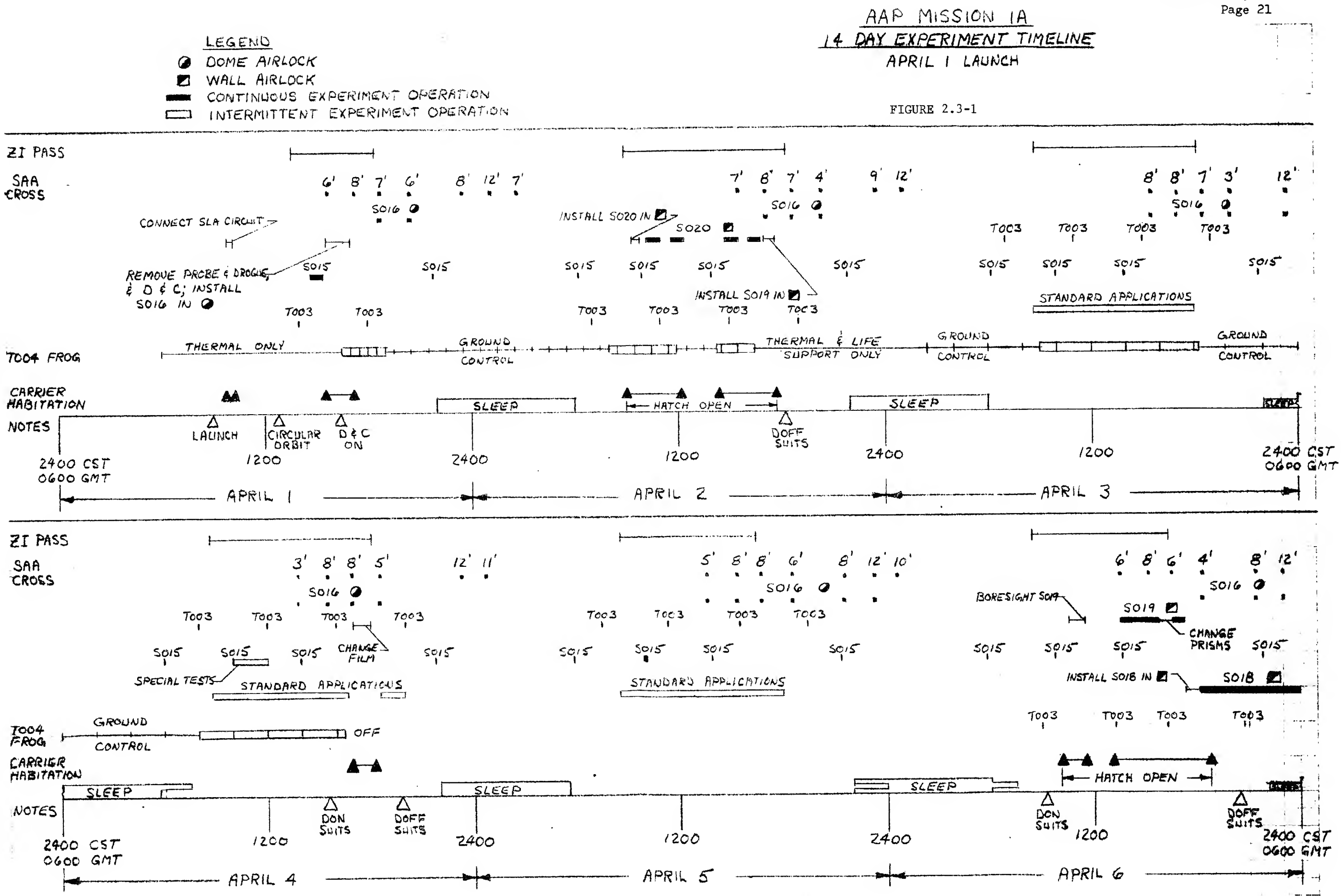
Experiment timelines are derived by considering (1) experiment operation time requirements, (2) target areas, (3) ground net, (4) crew activities, and (5) subsystem capabilities. Compromises are required in all these areas to obtain a workable operating schedule which satisfies most of the experiment objectives.

Experiment timelines are shown in Figures 2.3-1 and 2.3-2. Figure 2.3-1 shows a typical AAP-1A Mission 14-day timeline in which crew activities are integrated into the experiment operation cycles. Launch time is selected to maximize daylight passes over the United States. The first day is used primarily for orbit insertion and on-orbit preparations for the mission. With the exception of the micrometeoroid collection and several attitude oriented passes through the South Atlantic Anomaly, the seventh day is reserved for rest, housekeeping, and as a day in which events requiring rescheduling can be performed. The last two days are reserved for film and experiment retrieval, and preparation for re-entry and recovery. The remainder of the mission is available for spacecraft operations, experiments, and crew activities. Passes through the South Atlantic Anomaly are shown, including the time that spacecraft is within the Anomaly area.

Crew activities are arranged to enable the crew to eat and sleep as a group; however, sleep cycles have been staggered somewhat to maximize operation of experiment S016. Ten entries into the carrier are required during the mission. Operation of the earth resources and meteorological sensors are defined

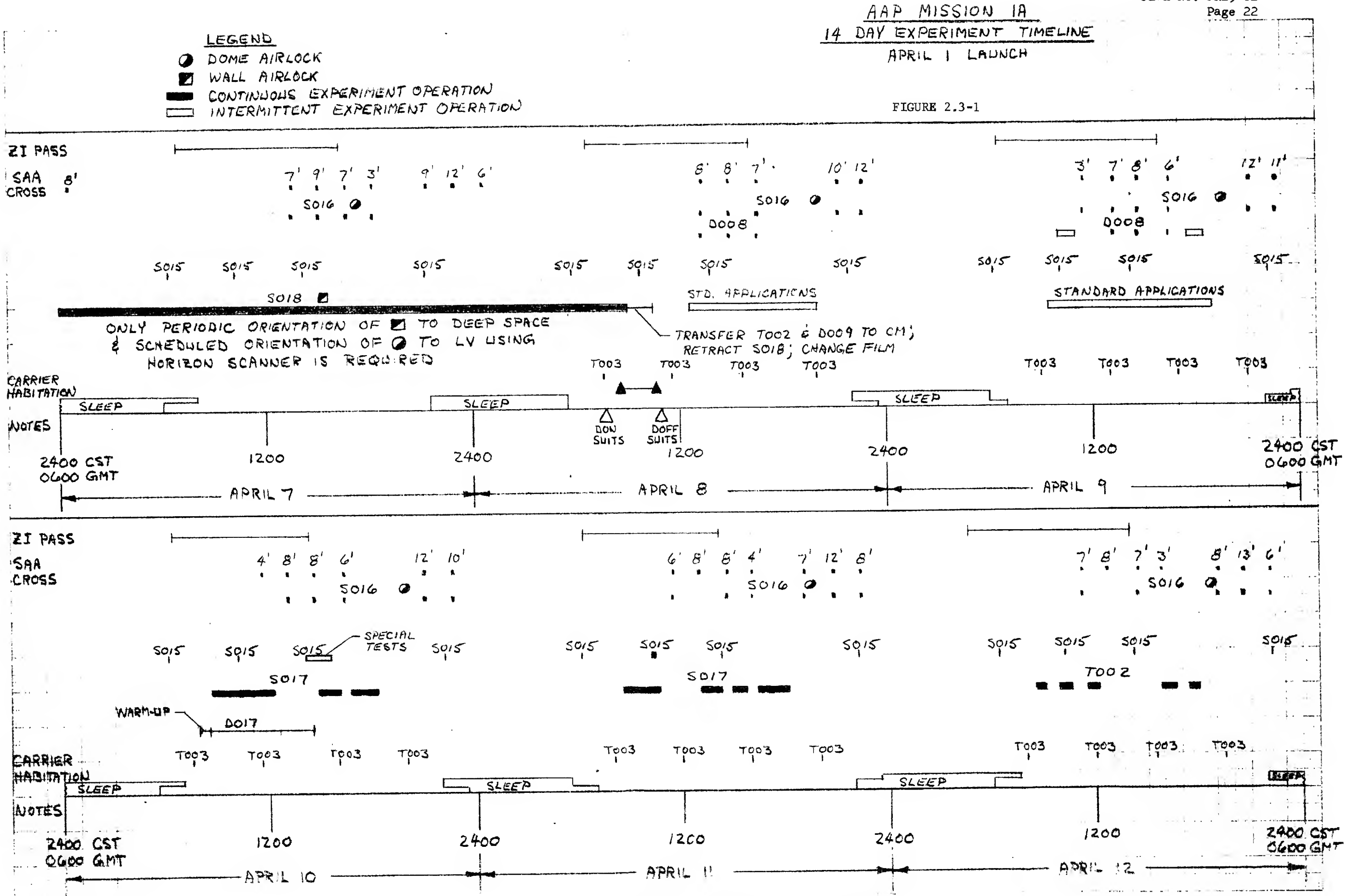
AAP MISSION 1A
14 DAY EXPERIMENT TIMELINE
APRIL 1 LAUNCH

FIGURE 2.3-1



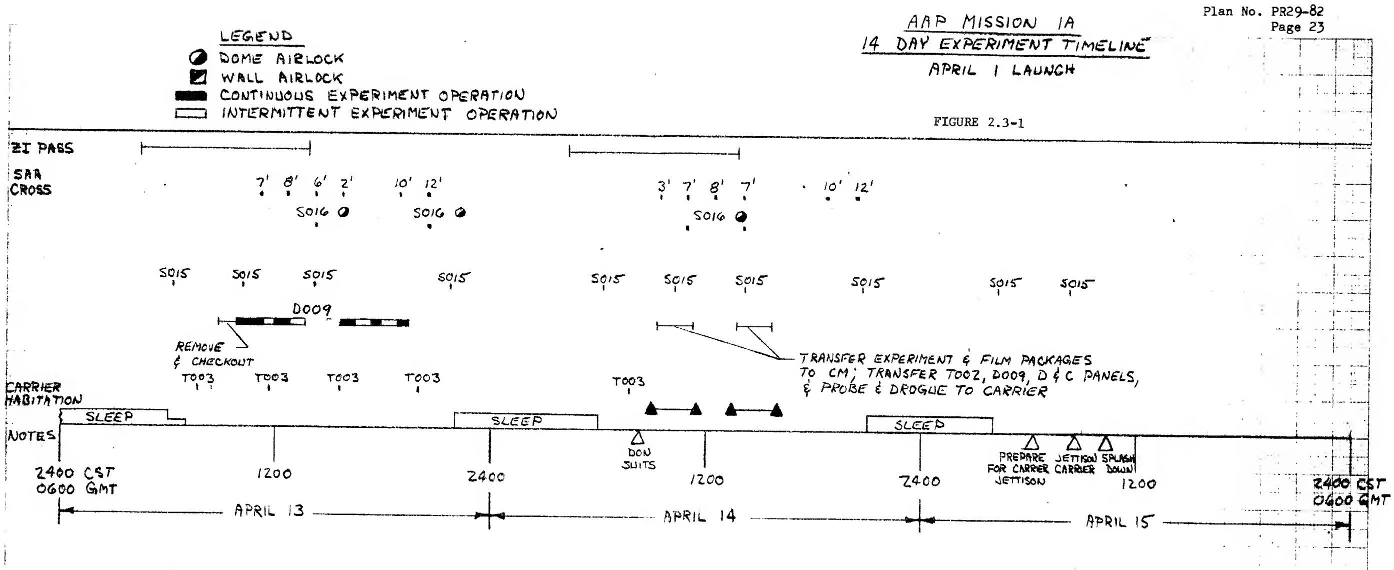
AAP MISSION 1A
14 DAY EXPERIMENT TIMELINE
APRIL 1 LAUNCH

FIGURE 2.3-1



AAP MISSION 1A
14 DAY EXPERIMENT TIMELINE
APRIL 1 LAUNCH

FIGURE 2.3-1



AAP MISSION IA
STANDARD APPLICATIONS
DAY 5 TIMELINE

FIGURE 2.3-2

9-8-67 W. CARMEAN

CODE

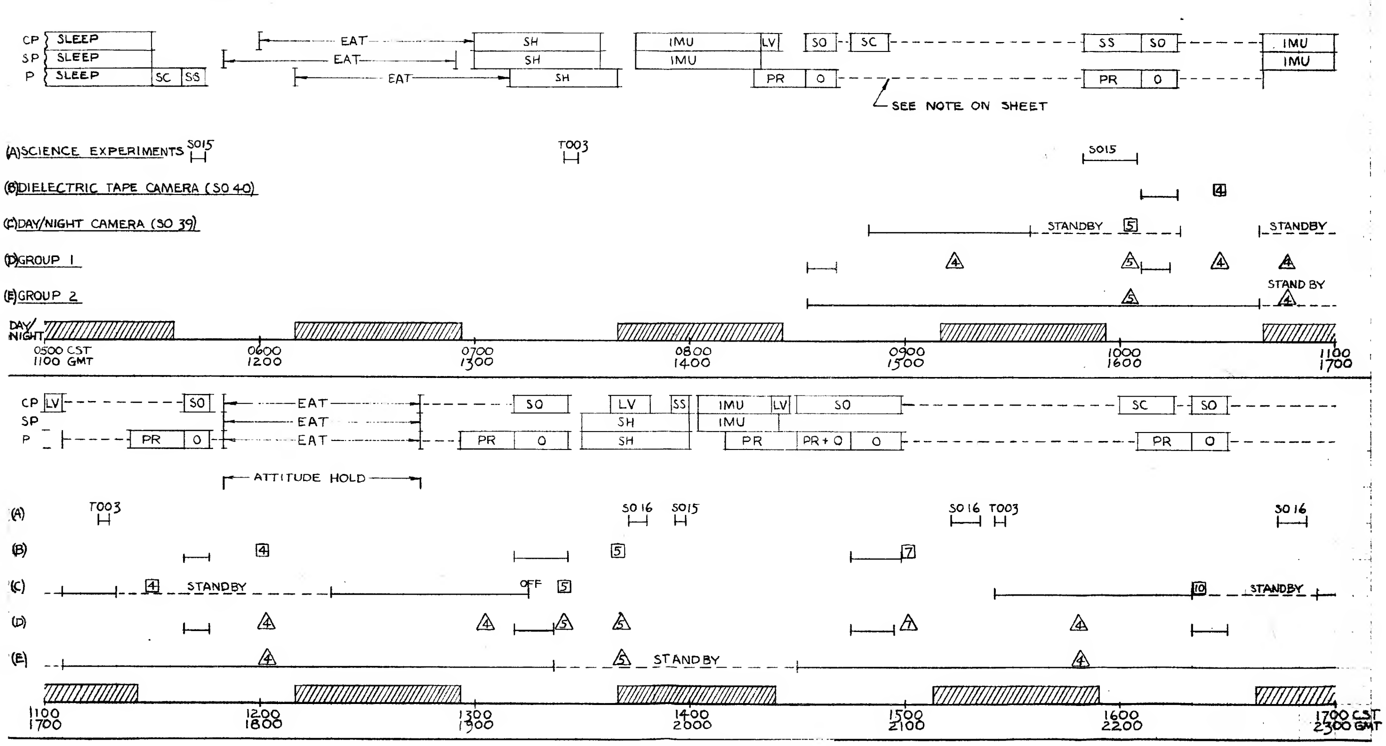
SS SUPPORT S015
SH SYSTEMS HOUSEKEEPING
IMU IMU ALIGNMENT
LV LOCAL VERTICAL ORIENTATION
PR PREP EXPERIMENT
O OPERATE EXPERIMENT
SO SUPPORT EXPERIMENT OPERATION
△ DATA DUMP VHF (MINUTES)
□ DATA DUMP S-BAND (MINUTES)

(D) EXPERIMENT GROUP 1

E06-1 METRIC CAMERA
E06-4 MULTISPECTRAL CAMERA
E06-7 IR IMAGER
E06-9A IR RADIOMETER
E06-9B IR SPECTROMETER
E06-11 PASSIVE M.W. RADIOMETER

(E) EXPERIMENT GROUP 2

S043 IR TEMPERATURE SOUNDER (TARGETS OF OPPORTUNITY)
S044A ELECTRICALLY SCANNED MICROWAVE RADIOMETER
S048 UHF SFERICS



MARTIN MARIETTA CORPORATION
DENVER DIVISION

AAP MISSION IA
STANDARD APPLICATIONS
DAY 5 TIMELINE

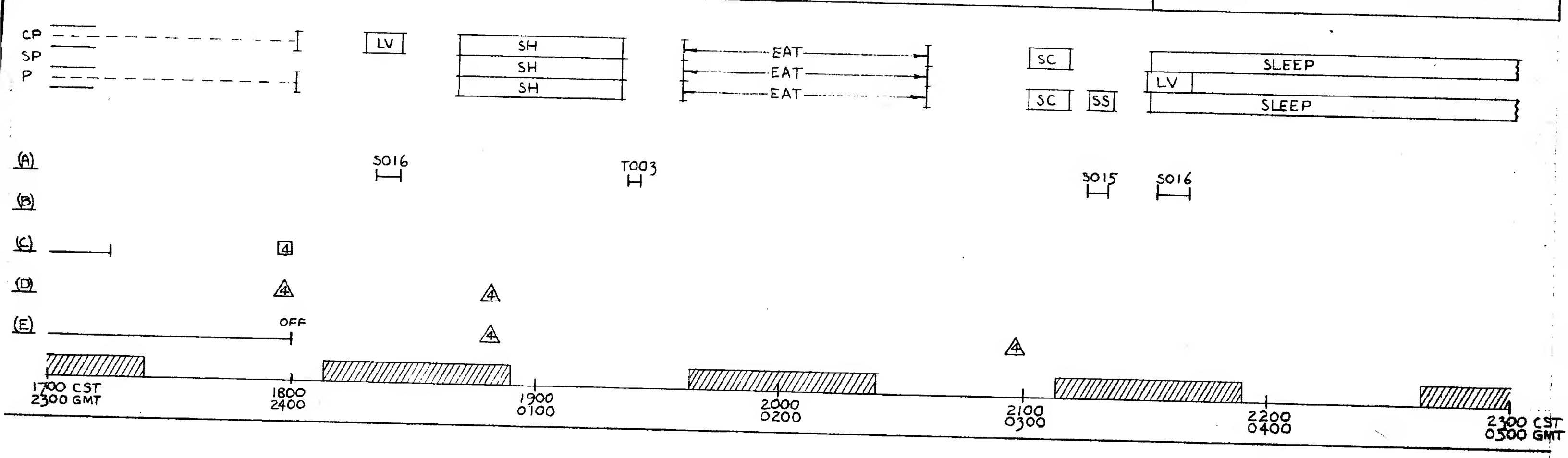
FIGURE 2.3-2

9-8-67 W. CARMEAN

CODE

- SS SUPPORT S015
- SH SYSTEMS HOUSEKEEPING
- IMU IMU ALIGNMENT
- LV LOCAL VERTICAL ORIENTATION
- PR PREP EXPERIMENTS
- O OPERATE EXPERIMENT
- SO SUPPORT EXPERIMENT OPERATION
- △ DATA DUMP VHF (MINUTES)
- □ DATA DUMP S-BAND (MINUTES)

(A) SCIENCE EXPERIMENTS
(B) DIELECTRIC TAPE CAMERA (S040)
(C) DAY/NIGHT CAMERA (S039)
(D) GROUP 1 (SEE SHEET 1)
(E) GROUP 2 (SEE SHEET 1)



NOTE: ALL THREE CREWMEN MAY ROTATE RESPONSIBILITY FOR CONTROLLING VEHICLE + MONITORING DAY/NIGHT CAMERA + GROUP 2 EXPERIMENTS DURING EXTENDED PERIODS OF OPERATION. THESE PERIODS ARE INDICATED BY ├ - - - - - - - - -┤

as the Standard Applications Day, due to concurrent operation of these sensors. These operations are available during five of the mission days. The Standard Applications Day is shown in more detail in Figure 2.3-2. Two basic experiment groupings are shown. Group 1 contains primarily the earth resources experiments which operate over the continental United States and coastal waters. Group 2 experiments operate continuously during much of the Standard Applications Day. The Day/Night Camera and the Dielectric Tape Camera are shown separately from the other experiments, since operation of these two is limited by data storage and by time over telemetry stations for data dump. Available time (in minutes) over telemetry stations is indicated by the numbers within the square and triangle symbols.

2.4 Trade Studies

2.4.1 PR 29-32 - Scientific Airlock Study

Two possible locations exist for the scientific airlocks which are available from the Block I CM. These are the equivalent position in the Block II CM (main access hatch) or the experiment carrier. Considerations of the modifications required, crew safety, and simultaneous operation of experiments has led to a decision to propose two scientific airlocks to be mounted, without modification, in the carrier - one located forward through the dome and one laterally through the carrier wall. Both airlocks are to be operated by an astronaut inside the carrier. This proposal also requires minimum change to the experiments that use the airlock.

2.4.2 PR 29-31 - Scientific Experiment Location

Each scientific experiment was reviewed for objectives, weight, volume, use, and stowage to determine optimum location during boost, orbit, use, and re-entry (if returned). Where alternatives existed, the CM weight and stowage requirements were minimized. Results of the study are summarized in Table 2.4-I, Experiment Locations.

2.4.3 PR 29-30 - Scientific Experiment Modifications

Each scientific experiment was reviewed for modifications to itself and to the CM. The results are shown in Table 2.4-II, Scientific Experiment Modification.

Table 2.4-I, Experiment Locations

EXPERIMENT	BOOST OR STOW	USE	FINAL DISPOSITION	RETURN ITEMS
C008 Radiation Monitors	CM	CM	CM	6 Dosimeters (5 lb.)
D009 Simple Navigation	In carrier	CM Window	In Carrier	Log Books (0.5 lb.)
D017 CO_2 Reduction	Outside Carrier	Outside Carrier	Outside Carrier	
T002 Manual Navigation Sighting	In carrier	CM Window	CM	1 Sextant (6.5 lb.)
T003 Aerosol Particle Analyser (Inflight Nephelometer)	CM	CM	CM	Nephelometer (5.5 lb.)
T004 Frog Otolith Function	Outside Carrier	Outside Carrier	Outside Carrier	
S015 Zero-G Single Human Cell	CM	CM	CM	Camera/Microscope Bio Packs (22 lb.)
S016 Trapped Particle Asymmetry	In carrier	Carrier Airlock	CM	Nuclear Emulsion (8 lb.)
S017 X-Ray Astronomy	Outside Carrier	Outside Carrier	Outside Carrier	
S018 Micrometeorite Collection	In carrier	Carrier Airlock	CM	Collection Device (6 lb.)
S019 UV Stellar Astronomy	In carrier	Carrier Airlock	CM	Spectrometer/Film (43 lb.)
S020 UV X-Ray Solar Photography	In carrier	Carrier Airlock	CM	Spectrograph/Film (25 lb.)
Applications Experiments	Carrier	Carrier	Carrier	Film (49.0 lb.)

Table 2.4-II Scientific Experiment Modifications

Experiment	Experiment Modifications	Command Module Modifications
D008 Radiation Monitors	No experiment hardware Design modifications required	1. Requires mounting provisions for 5 passive dosimeters and 1 active dosimeter. 2. Need power and data interface with active dosimeter.
D009 Simple Navigation	No experiment hardware design modifications required	1. Provide mounting position for sextant and stadimeter between sighting sequences.
D017 CO_2 Reduction	No experiment hardware design modifications required	N/A
T002 Manual Navigation Sightings	1. Possible modification or replacement of experiment cable assembly.	1. Requires interfaces with CM data system for "time-hack". 2. Provide stowage provision for re-entry. 3. Provide mounting position for sextant between sighting sequences
T003 Aerosol Particle Analyzer (Inflight Nephelometer)	1. Remove velcro tape and provide other suitable mounting hardware.	1. Provide appropriate mounting interface for analyzer. 2. Provide stowage.
T004 Frog Otolith	No experiment hardware design modifications required.	N/A
S015 Zero-G Single Human Cells	1. Remove velcro tape and provide other suitable mounting hardware. 2. Possible modification or replacement of experiment cable assembly.	1. Provide power interface with experiment package. 2. Provide new stowage location if presently designed location is not available.
S-16 Trapped Particle Asymmetry	1. Modify main emulsion package to provide an approximate 45° inclination of emulsion to airlock extension rod.	1. Provide stowage provision for re-entry.

Table 2.4-II Scientific Experiment Modifications (Cont'd.)

Experiment	Experiment Modifications	Command Module Modifications
S017 X-Ray Astronomy	1. Modify input circuitry to experiment tape recorder (part of S017 data package) to permit time-share recording with earth resources experiments. 2. Repackage transmitter.	1. Provide mounting provision in vicinity of IMU sextant for S017/T004 control unit. 2. Provide G&N PCM word, G&N start and 51.2KC clock to CM/carrier interface.
S018 Micrometeorite Collection	No experiment hardware design modifications required.	1. Provide stowage provision for re-entry.
S019 UV Stellar Astonomy	1. Possible modification or replacement of experiment stowage bracket assembly. 2. Current study by hardware contractor to examine film extraction feasibility.	1. Provide stowage provision for re-entry.
S020 UV X-Ray Solar Photography	1. Possible modification or replacement of experiment data/power cable assembly. 2. Current study by hardware contractor to examine film extraction feasibility.	1. Provide stowage provision for re-entry.

Note:

1. This table does not include any equipment modifications that may be required as a result of non-metallic compatibility analysis.

2.4.4 PR 29-29 - Experiment S019 and S020 Film Extraction

These two experiments were reviewed to determine if it was feasible to remove the film and leave the body of the experiment in orbit. The conclusion was reached that the present hardware is not capable of inflight film extraction. Further, there is capability in the CM for returning the experiment's weight and volume.

2.5 Experiment Operational Requirements -

2.5.1 Experiment Utilization -

Experiment utilization resulting from the mission timelines is summarized in Tables 2.5-I and 2.5-II. The requested experiment operating time is shown, with the percentage of this requested time available on the reference mission. Most of the objectives of the earth resources and meteorological experiments (Table 2.5-I) are completely satisfied. The Day/Night and Dielectric Tape Cameras are exceptions, primarily due to data storage and playback limitations. The UHF series objective of continuous operation for 11 days is not achieved, however, it and the other continuous operating experiments of Group 2 are operated for nearly 4 days (46 hours).

The science experiment operating time objectives (Table 2.5-II) are nearly all satisfied. Limitations result due to limited crew time for the Manual Sightings, Trapped Particles, UV Stellar Astronomy, and UV X-Ray Solar Photography experiments. Reaction control propellant limitation of 270 pounds total for experiment operation will reduce S017, X-Ray Astronomy by 10%. However, adequate operation time is provided for all the listed science experiments to provide adequate data for post-mission interpretation.

2.5.2 Simultaneous Experiment Operation for Complementary Data

The applications experiments are categorized in earth resources or atmospheric environment disciplines. Within each discipline, complementary data can be obtained by simultaneous operation of two or more experiments, thus enhancing interpretation and analysis of individual experiment data.

Shown in Table 2.5-III are experiment requirements for simultaneous operation and percentage of simultaneous

TABLE 2.5-I APPLICATIONS EXPERIMENTS UTILIZATION

EXPERIMENT		REQUESTED	% OF REQUEST
(E06-1)	METRIC CAMERA	900 FRAMES	100% (GROUP 1)
(E06-4)	MULTISPECTRAL CAMERA	540 FRAMES	100% (GROUP 1)
(E06-7)	IR IMAGER	100 FT FILM, 11 HRS	100% (GROUP 1 - 5 HRS) (GROUP 2 - 6 HRS)
(E06-9A)	IR RADIOMETER	30 TARGETS 7 MIN/TARGET	100% (GROUP 1)
(E06-9B)	IR SPECTROMETER	30 TARGETS 7 MIN/TARGET	100% (GROUP 1)
(E06-11)	MULTIFREQUENCY MICROWAVE RADIOMETER	30 TARGETS Z.I. AND COSTAL WATERS	100% (GROUP 1)
(S039)	DAY-NIGHT CAMERA	(A) AUTOMATIC MODE-CONTINUOUS DURING APPLICATIONS DAY	50%
		(B) MANUAL MODE - 4 HRS	100%
(S040)	DIELECTRIC TAPE CAMERA	CONTINUOUS DURING APPLICATIONS DAY (DAYLIGHT ONLY)	20%
(S043)	IR TEMPERATURE SOUNDER	50 TARGETS OF OPPORTUNITY	100% (GROUP 2)
(S044A)	ELECTRICALLY SCANNED MICROWAVE RADIOMETER	CONTINUOUS DURING APPLICATIONS DAY	100% (GROUP 2)
(S048)	UHF SFERICS	(A) AUTOMATIC MODE-CONTINUOUS FOR 11 DAYS	17% (GROUP 2)
		(B) MANUAL MODE - 4 HRS, DARK ONLY	100% (GROUP 2)

GROUP 1 EXPERIMENTS _ THIRTY OPERATIONS OVER ZONE OF INTERIOR (5 HRS TOTAL)

GROUP 2 EXPERIMENTS - FIVE OPERATIONS (46 HRS TOTAL)

TABLE 2.5-II

EXPERIMENT OPERATION UTILIZATION - PERCENT OF DESIRED OPERATION

EXPERIMENT		REQUESTED	% OF REQUEST TIMELINE CONSIDERATIONS	TIMELINE & RCS CONSIDERATIONS
T002	MANUAL SIGHTINGS	56 PERIODS OF 20-30 MIN. EA.	15% *	15%
T003	NEPHELOMETER	EVERY 4 HRS EXCEPT SLEEP	100%	100%
T004	FROG OTOLITH FUNCTION	CONTINUOUS FOR 72 HRS. FROM LAUNCH	100%	100%
D008	RADIATION MONITORS	CONTINUOUS & SPECIAL TESTS (3 IN SAA, 3 OUT)	100%	100%
D009	SIMPLE NAVIGATION	1 WORK CYCLE	100%	100%
D017	CO_2 REDUCTION	ANY 6 HOUR PERIOD	100%	100%
S015	HUMAN CELLS	FEED EVERY 12 HOURS, PHOTO 6 HRS. EXCEPT SLEEP	100%	100%
S016	TRAPPED PARTICLES	80% OF PASSES THRU SAA @ 140 NM	92% *	92%
S017	X-RAY ASTRONOMY	20 SIGHTINGS	100%	90% **
S018	MICROMETEORITE COLLECTION	8 TO 40 HOURS EXPOSURE	100%	100%
S019	UV STELLAR ASTRONOMY	135 EXPOSURES	75% *	75%
S020	UV X-RAY SOLAR PHOTO-GRAPHY	10 SIGHTINGS, LIGHT ONLY	60%	60%

* LIMITED CREW TIME

** LIMITED RCS (270 LB. FOR EXPERIMENT OPERATION)

Table 2.5-III Experiment Requirements for Simultaneous Operation of Supporting Experiments

Experiment Title	Required Support From	Required Support Sched.	Desired Support From	Desired Support Sched.
Metric Camera E06-1			E06-4 E06-7	100% 100%
Multispectral Camera E06-4	Attitude Reference	100%		
IR Imager E06-7	E06-4 E06-9 Support Camera	100% 100% 100%		
IR Radiometer/ Spectrometer E06-9	Support Camera Attitude Ref.	100% 100%	S043	67%
Passive Microwave Radiometer	E06-9 S044A Support Camera Attitude Ref.	100% 67% 100% 100%	S043	67%
Day/Night Camera S039			E06-4 E06-7 S040 S043 S044A S048	33% 33% 33% 100% 100% 100%
Dielectric Tape Camera S040	S039	33%		
IR Temperature Sounding S043	S039 Attitude Reference	50% 100%		
Elect. Scanned MW Radiometer S044A	S043 Support Camera Attitude Ref.	100% 100% 100%	E06-11	10%
UHF Sferics S048	S043 Attitude Ref.	100% 100%		

operation time scheduled. In addition, the desired supporting experiments and percentage operation times are shown. Note that most required support has been scheduled for 100% simultaneous operation, and that all required and desired support has been scheduled for at least some simultaneous operation.

2.5.3 Experiments Seasonal Requirements -

Of the currently designated group of experiments for the AAP-1A flight, only those experiments in the earth resources and atmospheric environment disciplines have explicit seasonal preferences. These preferences are shown in the bar chart (Table 2.5-IV). The rationale for these preferences are as follows:

- Metric Camera - The desired conditions for this experiment are good illumination and minimum foliage cover of ground structure. The preferred period is during September and November with a less desirable period during April and May. June, July and August are marginal because of heavy foliage cover and December, January, February and March are marginal because of poor lighting.

- Multispectral Camera - The desired conditions are good illumination and a wide variety of foliage. Preferred months are May through September. Marginal months are October through April.

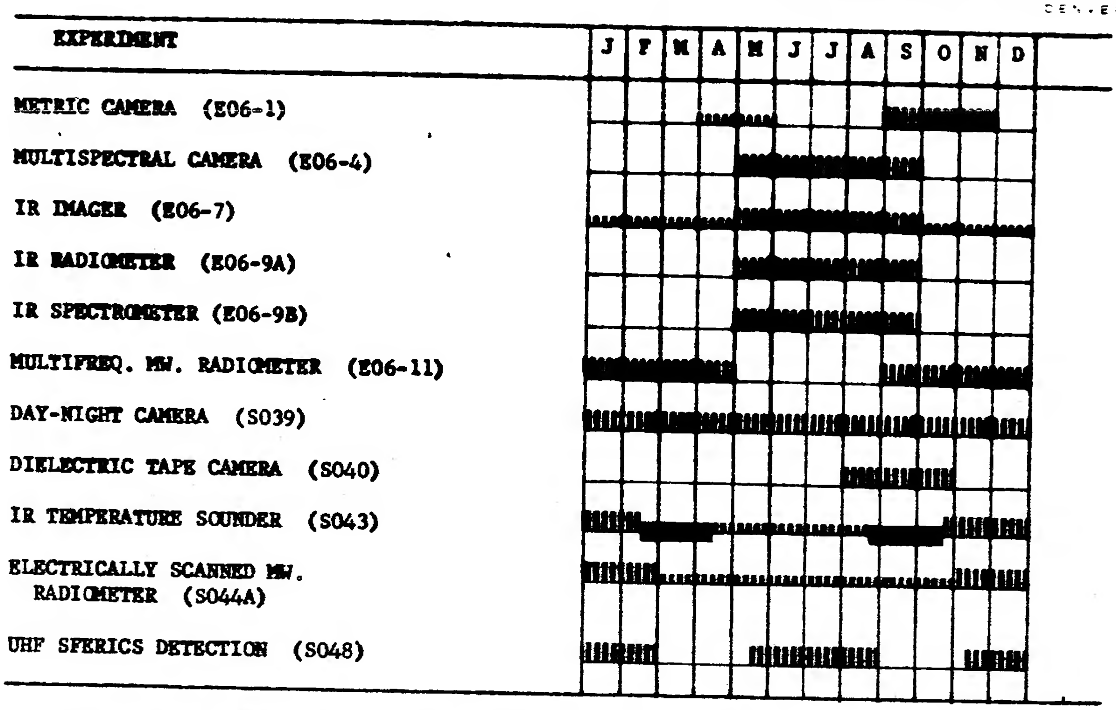
- IR Imager - The primary experiment objectives are forestry/agriculture. This gives a slight preference for the period from May through September. All seasons are acceptable.

- IR Radiometer - The primary objectives are in the area of geological studies. Snow cover would be detrimental to the performance of the experiment. Preferred period is then May through September.

- IR Spectrometer - Same considerations as IR Radiometer.

- Multifrequency Microwave Radiometer - The preferred period is September through April based on the desire to study the following features: 1) ice pack formation in the Great Lakes, 2) a range of defoliation in deciduous forest regions, and 3) size and distribution of snow fields.

TABLE 2.5-IV EXPERIMENTS SEASONAL REQUIREMENTS



PREFERRED ACCEPTABLE MARGINAL UNACCEPTABLE

NOTE: REMAINING EXPERIMENTS HAVE NO SEASONAL REQUIREMENTS

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- Day/Night Camera - No seasonal preference.

- Dielectric Tape Camera - The preferred period from August through October is the time of highest incidence of hurricanes, tornadoes, and thunderstorms.

- IR Temperature Sounder - A maximum range of temperature variation over the earth is desired. There is a slight preference for the winter season in the Northern Hemisphere. The equinox periods are to be avoided because of the similarity of conditions in the two hemispheres, and are considered unacceptable by the PI.

- Electrically Scanned Microwave Radiometer - There is a slight preference for the Northern Hemisphere winter season November through February because of a wider temperature range of targets in the ZI region. The features of interest are approximately the same as for the multifrequency microwave radiometer.

- UHF Series Detectors - Preferred periods are mid-May through August and Mid-November through February. These are the periods of maximum thunder storm activity in either the Northern or Southern Hemisphere.

The conclusions to be drawn from this chart are a) the optimum launch period from seasonal requirement considerations is from mid-April through mid-October. The low spot in the preference curve during this period is mid-June to mid-July and the high from mid-August to mid-September. A flight mission ready for April would be available for an optimum launch over the next 6 months. b) the least desirable periods are mid-December to mid-January and mid-February to mid-April.

2.6 Experiment Availability Schedule

Experiment availability estimates were obtained to determine the available launch date. NASA/MSC and experiment contractors provided the estimates for GFE and CFE experiments, respectively. Availability dates are based on contract receipt by the experiment contractors in November of 1967 for CFE items. It is assumed that preparation of Procurement Documents can be expedited prior to Phase D go-ahead to allow early placement of CFE contracts with experiment contractors.

Figure 2.6-1 shows the resulting schedule/availability for the earth resources and meteorological experiments. A check of the carrier build/test cycle shows that an integration unit of most of the experiments will be available for the beginning of carrier systems tests. Three experiments are late for the carrier systems tests. These will require negotiation and/or premium time to be compatible with the proposed systems test schedule.

Flight units for three experiments (multispectral camera, day-night camera, and dielectric tape camera) are not available for a January launch; but all experiments appear compatible with an April, 1969 flight. A January launch would then require that the day-night and dielectric tape cameras be deleted, or their development accelerated. The multispectral cameras would become CFE equipment, probably not of the multiple Hasselblad configuration. The resulting multispectral camera experiment weight will be nearly the same as that of the combined Hasselblad cameras and film magazines.

Generally, qualification units are not considered to be refurbished for use as flight units. However, refurbishment of the day-night and dielectric tape camera is required for the April launch. All of the science experiments are available for the earliest launch of the earth resources and meteorological experiments.

FIGURE 2.6-1
EXPERIMENT SCHEDULE/AVAILABILITY

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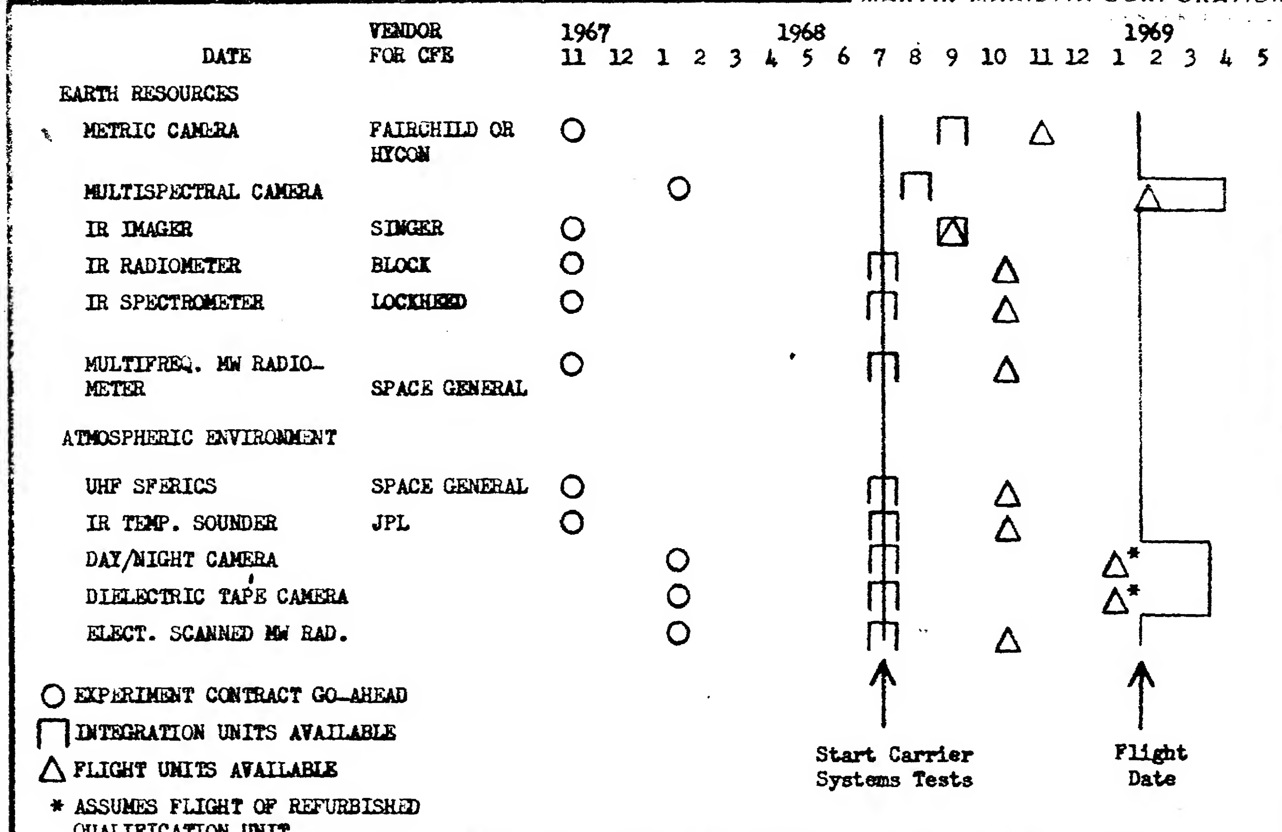


NOTE: ALL SCIENCE EXPERIMENTS AVAILABLE FOR JANUARY FLIGHT

3. MISSION AND CREW INTEGRATION

3.1 Mission Analysis/Flight Operations

3.1.1 Summary - The AAP-1A primary mission goal is to conduct meteorology, earth resources, astronomical and bioscience experiments in a low altitude, high inclination earth orbit for a period up to 14 days. To satisfy this goal and to provide a planning baseline for system and subsystem design, a mission profile has been defined and operational tasks and hardware have been integrated indicating a feasible approach. Step-by-step coordination with MSC mission planning personnel have produced the study results described in the following paragraphs. Future efforts will be directed toward the optimization of time, crew, and equipment utilization to maximize the value of the mission.

3.1.2 Overall Mission Analysis

3.1.2.1 Baseline - For this study, the AAP-1A mission is constrained to a single uprated Saturn IB launch from KSC in the time period of 1 September 1968 to 1 July 1969. The S-IVB stage will have single start capability. The payload will be composed of a CSM, carrier and experiments. The CSM will be an unmodified Block II CSM and resupply will not be considered. The basic payload carrier and experiments will weigh less than 5000 pounds. All data and communications will be managed through the existing MSFN (refer to PR29-19, Revised Ground Track, MSFN and Truth Site Data) for the mission time period. The target mission duration will be open-ended to 14 days and the earth targets and truth sites will be situated in the Continental United States and adjacent sea areas. A complete discussion of requirements and constraints is presented in Paragraph 1.3.

3.1.2.2 Mission Considerations - A trade study (refer to PR 29-1, Optimum Orbit Inclination) indicates that inclinations between 44 and 50 deg provide the best viewing of potential targets in the Continental United States. While the lower inclinations may be better for certain experiment packages a 50 deg inclination has been selected to maximize the

3.1.2.2 (Continued)

the mission potential. The 50 deg inclined orbit exhibits a payload capability of about 700 lbs less than that at 44 deg.

A northerly launch is a consequence of the high orbit inclination where launch vehicle yaw steering is unacceptable from the standpoint of payload performance. The maximum inclination for a southerly launch without yaw steering or major land overflight is about 42 deg and for northerly launches the maximum inclination is approximately 54 deg.

The high inclination and northerly launch leads to an additional profile parameter; the injection altitude. An injection altitude of 87 n.m. is required from launch abort considerations (specified by MSC). Therefore the booster ascent path will provide for injection into an 87 x 140 n. m. ellipse to be circularized at the third apogee by the CSM-SPS. The 140 n.m. final mission altitude is sufficiently high to provide 14 days of mission duration without orbit keeping and yield a ground trace pattern that nearly repeats in 5 days. A slightly higher altitude would yield a repeating orbit if desired. The 140 n.m. altitude is favorable for optical viewing of the earth's surface and compatible with the baseline experiment requirements shown in Paragraph 2.2. Circularization is delayed to third apogee to provide time for CSM transposition and docking to the carrier and S-IVB jettison, systems checks and preparation for the circularization burn.

The launch vehicle performance has been defined by NASA as 36,500 lbs of payload injected into an 87 x 140 n.m. elliptic orbit. The launch azimuth is 44.6 deg. This 36,500 lbs includes 3947 lbs for the SLA and 25,198 lbs for the CSM with RCS propellants. In addition, 1472 lbs of SPS propellant is required and 5000 lbs are allocated to experiments and carrier. This allocation of payload leaves 883 pounds as margin. The weight statement is summarized in Figure 3.1.2-1 and a propellant budget supplied

50° INCLINATION - NORTHERLY LAUNCH	87 x 140 n m		67,100 lbs
SIVB JETTISON WT		34,547 lbs	
PAYLOAD PLUS 3947 SLA			36,500 lbs
CSM			
BASIC 23,974	25,198		
RCS 1,224			
SPS FINAL ORBIT 318	1,472		
SPS RETRO 1,154			
		26,670 lbs	
PAYLOAD CAPABILITY	140 n m circ		5,883 lbs
ALLOWABLE CARRIER AND EXPERIMENT			5,000 lbs
MARGIN			883 lbs

RCS PROPELLANT ALLOCATION FOR ORBIT OPERATIONS - 281 lbs

CM BOOST WEIGHT	33 lb
CM BOOST VOLUME	1 ft^3
CM REENTRY WEIGHT	219.9 lb
CM REENTRY VOLUME	6.6 ft^3
SPS-ORBITAL DRAG MAKEUP	0 lb

FIGURE 3.1.2-1, AAP-1A WEIGHT AND PERFORMANCE

3.1.2.2 (Continued)

by MSC is shown in Figure 3.1.2-2. Of the 1224 pounds of available RCS propellant, 281 pounds has been specified by the AAPO as the budget for all AAP-1A experiment and housekeeping requirements.

3.1.2.3 Study Results - The basic flight plan for the 1A flight is summarized as a starting point for the discussion of mission planning elements of the program. A single uprated Saturn 1B launch is assumed to take place from KSC on 1 April 1969 at 1000 EST. The boost vehicle will place the CSM and payload into an 87 x 140 n.m. elliptic orbit with the inclination of 50 deg. Injection will occur approximately 10 min and 14 sec after liftoff. During the next 2-1/2 orbit periods the system will be checked out, the SLA panels retracted, and the CSM will transpose and dock to the carrier. The CSM will extract the carrier from the S-IVB over West Texas approximately 1.5 hours after orbit insertion. (The jettisoned S-IVB is no longer used in the mission.) The spacecraft will then coast to third apogee where circularization will be accomplished by the CSM SPS. A 6 sec SPS burn is required. No additional orbit keeping or orbit adjustment maneuvers are anticipated. The baseline mission will continue for 14 days (14-24 hr periods), followed by retro velocity, reentry and recovery during calendar day 15. Retro velocity is supplied by the SM-SPS with an RCS backup. Primary recovery is planned in the vicinity of 60 deg west longitude 35 deg north latitude in the Atlantic Ocean. Figure 3.1.2-3 shows the mission profile. A primary consideration in mission planning and spacecraft design in the orientation of the vehicle during orbital experiment operations. Since the prime emphasis on the 1A mission is crew operated sensors which view the earth local vertical, and since the 5000 lb payload allowable represents a need to minimize and control weight, these two areas received major emphasis.

Figure 3.1.2-4 identifies the prime considerations for the candidate spacecraft orientations, streamlined, nose down and oblique. Early in the study period, the CM couches were selected as the primary astronaut work stations and window visibility was evaluated through the forward docking windows - the nose down attitude then appears best for the 1A mission requirements. Carrier weight for a pressurized carrier is minimized in the nose down configuration. Sensor contamination and plume impingement effects from the SM-RCS engines are minimized even without

	RCS	SPS
S-IVB/CSM SEPARATION AND PAYLOAD EXTRACTION	60	0
CIRCULARIZATION BURN	31	318
EXPERIMENTS AND ATTITUDE CONTROL	0	0
OTHER FUNCTIONS (IMU ALIGNMENTS, ETC.)	20	0
CONTINGENCY RCS DEORBIT	575	0
SPS DEORBIT	31	1154
CM/SM SEPARATION	35	0
PAYLOAD JETTISON	10	0
SUBTOTAL	762	1472
MISSION CONTINGENCY (10%)	76	147
GAUGING ERRORS (RCS 6% OF CAPACITY)	9	72
TOTAL USABLE REQUIRED	847	1691
TOTAL AVAILABLE	1224	1691
MARGIN	377	0
ALLOCATED TO 1A ORBITAL OPERATIONS (AAPO)	281	

SOURCE: MSC Letter G7FM 13-302

FIGURE 3.1.2.-2 PROPELLANT BUDGET

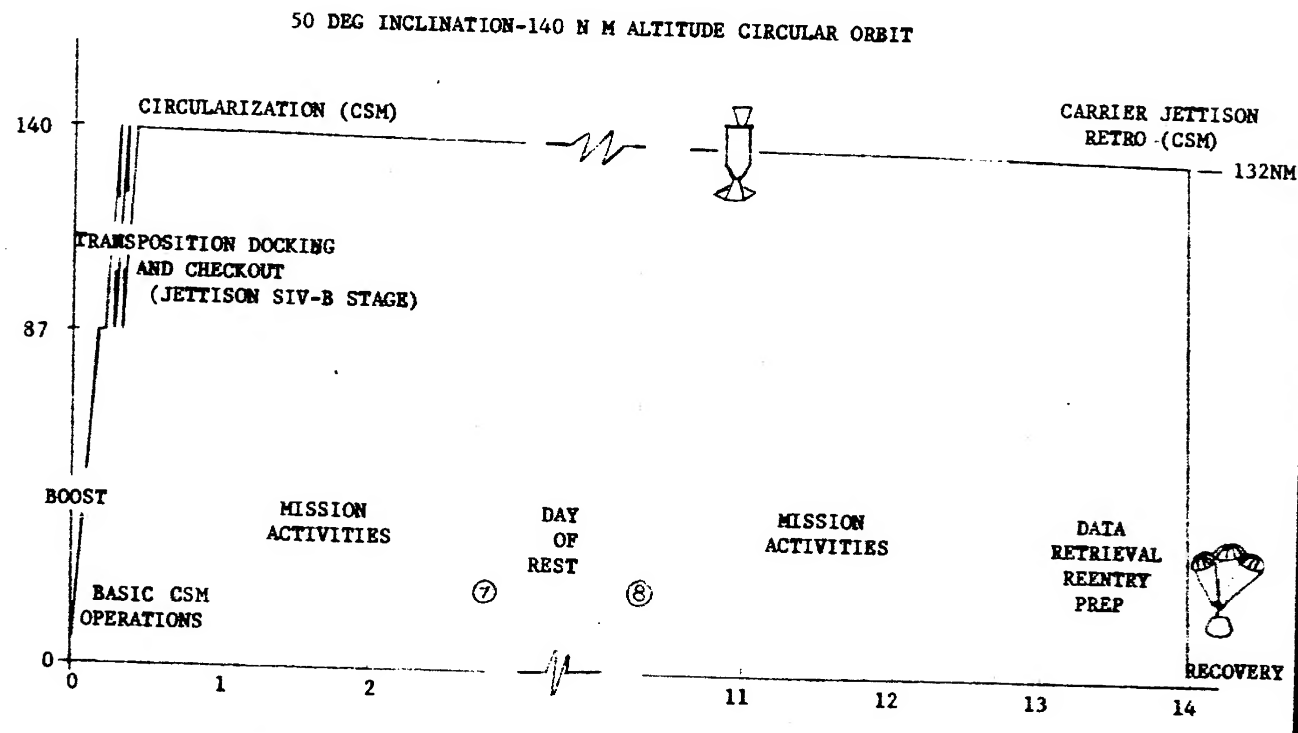
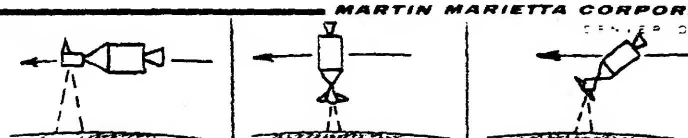


FIGURE 3.1.2-3 MISSION PROFILE



EARTH ORIENTATION / CONSIDERATIONS	STREAMLINED	NOSE DOWN	OBLIQUE
• CREW VISIBILITY			
ORIENTATION	HEADS DOWN	HEADS FORWARD	HEADS DOWN
FORWARD VIEW	VERY GOOD	VERY GOOD	LIMITED
NADIR VIEW	PRISM REQ'D	VERY GOOD	VERY GOOD
• CARRIER WEIGHT			
PRESSURE VESSEL	HIGH	LOW	MEDIUM
• NOMINAL ORBITAL DECAY (14 DAYS)	2.5 NM	8.5 NM	5.0 NM
• SENSOR CONTAMINATION (RCS)	INHIBIT FORWARD POINTING NOZZLES	MINIMAL WITHOUT NOZZLE INHIBIT	POSSIBLE WITH FORWARD NOZZLES
• RCS PROPELLANT USAGE ON TRACK OPERATIONS			
G & N AUTOMATIC MODE	LOW	POTENTIALLY LOW	POTENTIALLY LOW
MANUAL/SCS	MEDIUM	HIGH	MEDIUM
CROSSTRACK MANEUVERS	HIGH	MEDIUM	HIGH
• DISTURBING TORQUES			
AERODYNAMIC	LOW	HIGH	MEDIUM
GRAVITY GRADIENT	LOW	LOW	HIGH

FIGURE 3.1.2-4, AAP-1A SPACECRAFT ORIENTATION

3.1.2.3 (Continued)

nozzle inhibiting in the nose down mode. This is obvious in Figure 3.1.2-5 which shows the CSM/carrier from the earth sensor end, the RCS engines and the crew visibility over the carrier shell and truss work. Orbital decay, as well as RCS propellant usage for off-track maneuvers and corrections for disturbing aerodynamic torques is higher than the other configurations but still within the mission objectives and consumables budget. The nose down configuration was the prime selection considering both configuration and crew timeline factors.

Based on the local vertical orientation for the major part of the mission, the following vehicle aerodynamic characteristics are noted. The reference area in the nose-down orientation is 376.09 ft^2 while the streamlined value would be 129.28 ft^2. The C_DA value and hence the drag and decay rate is 3.73 times as great in the nose-down orientation as in the minimum drag orientation. The weight is assumed to be constant. An end-on C_D of 2.35 and a nose-down value of 3.0 are assumed. MSC computer analyses utilizing the MSFC dynamic atmosphere for the April launch date indicates a nominal decay of 8-1/2 n.m. after 14 days of nose-down operation; therefore, orbit keeping has not been considered.

The MSFN and simulation of the Continental United States is discussed in PR29-19, Revised Ground Track, MSFN and Truth Site Data. The MSFN definition used is shown in Figure 3.1.2-6. Simulation of the United States is achieved by locating three hypothetical stations (west, central, and east) whose visibility cones approximate the United States boundaries, and using these as inputs to the TRACE model.

Finally, a launch time and date definition is required. PR29-2, Comparison of Launch Time for Best Mission Operation, provides the trade-off considerations that lead to selection of 1000 EST (1500 GMT) April 1, 1969, as the baseline launch time. For this launch date solar lighting is optimized over the Continental United States throughout the 14 day mission and daylight recovery

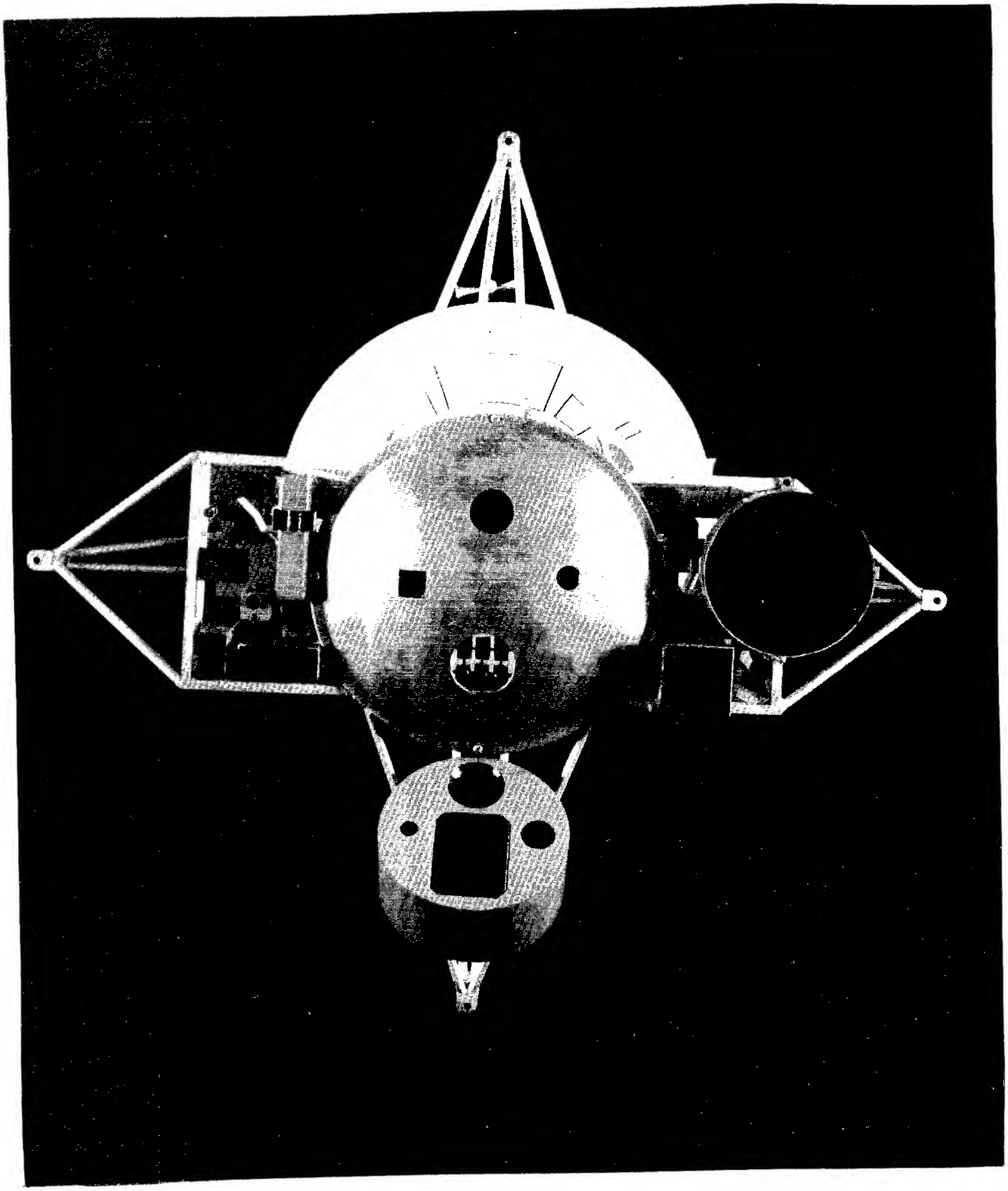


FIGURE 3.1.2-5, CSM WITH CARRIER (1/10 SCALE MODEL)

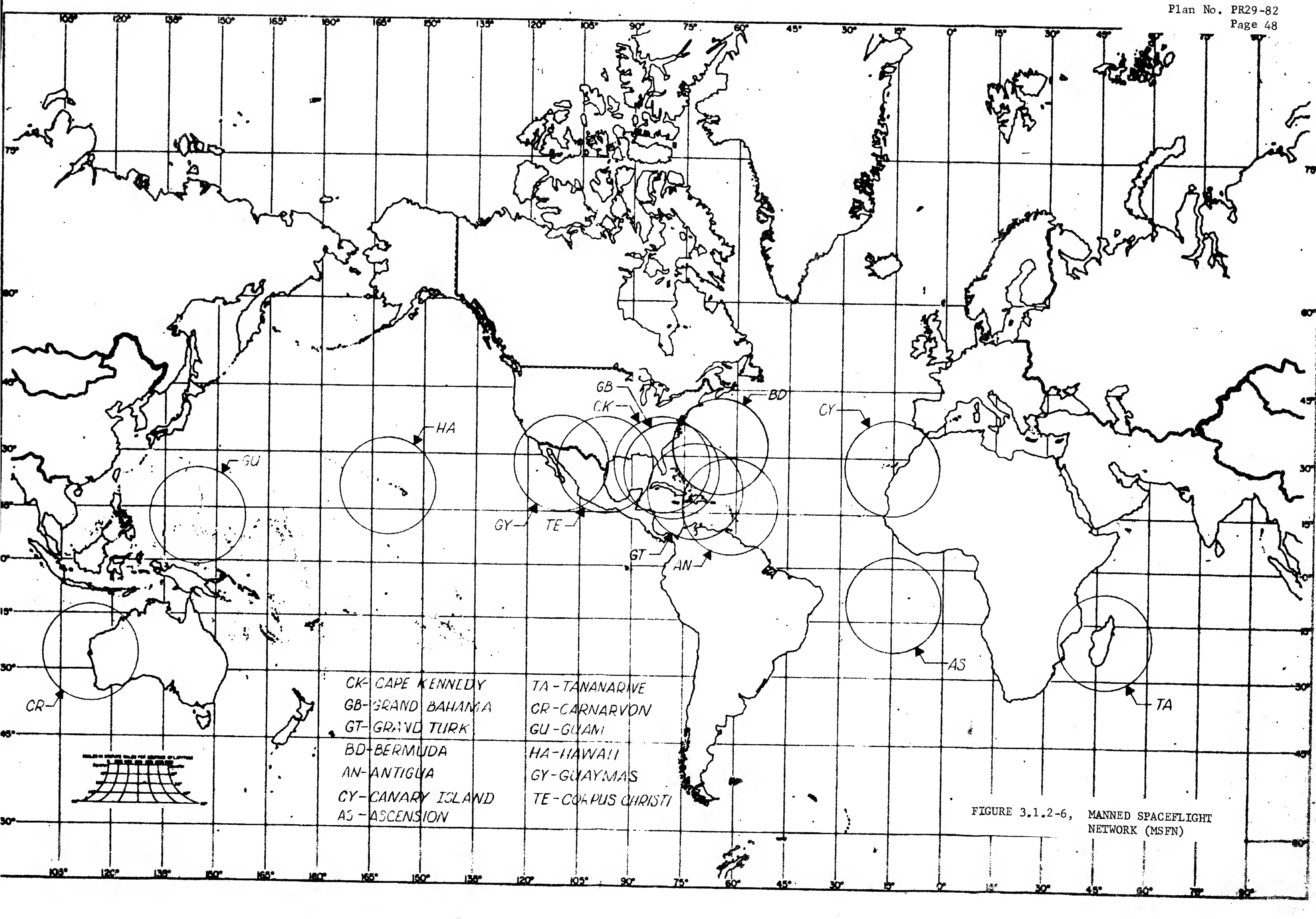


FIGURE 3.1.2-6, MANNED SPACEFLIGHT NETWORK (MSFN)

3.1.2.3 (Continued)

in the Atlantic Ocean on a descending pass is achieved. The launch date for optimum solar illumination of northern hemisphere targets falls between the first of March and the first of October*(Figure 3.1.2-7) where the solar altitude is above 30 degrees at 50 degrees north latitude. The 1000 EST launch keeps the northern limb of the orbit in daylight throughout the mission and provides for recovery around 35 degrees north latitude and 60 degrees west longitude between 1100 and 1200 EST (see Figure 3.1.2-8). Other launch date considerations are included in Paragraph 2.5.3.

The detailed ground trace data has been obtained from the TRACE digital computer program. These data are presented in total in PR29-19, Revised Ground Track, MSFN and Truth Site Data, and include orbital position in terms of latitude and longitude, daylight conditions and over station time for the entire 14-day mission. An important aspect of these data is the ground coverage and communications time.

Figure 3.1.2-9 presents the coverage pattern over the Continental United States on any one day. Subsequent day patterns shift westerly as noted by the single bars. A pattern of complete coverage of the United States in 5 days is achieved with a viewing angle of 40 degrees to either side of nadir. A minimum viewing angle of 30 degrees to either side of nadir would still provide complete coverage of the target area. This angle can be in the capability of the sensor or may be achieved by vehicle attitude change. A fourteen day history of ground tracks and time over station is presented in Trade Study PR29-19, Revised Ground Track, MSFN and Truth Site Data. Timelines showing use of these data are presented in Paragraph 2.3.

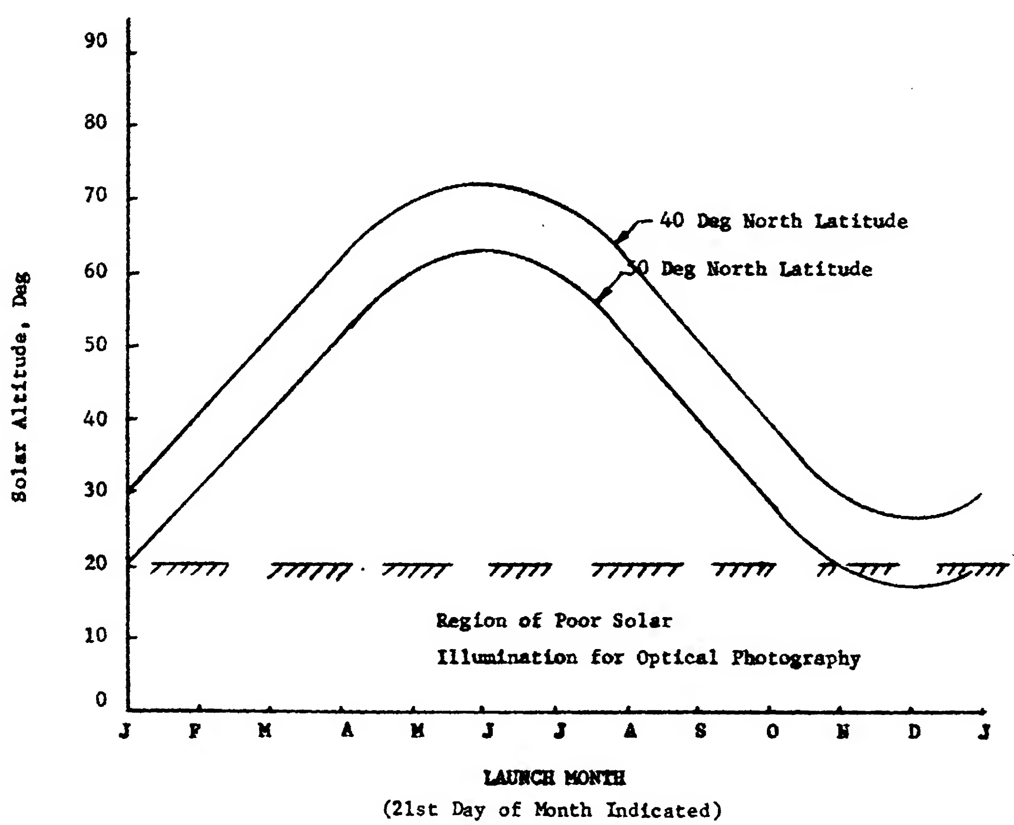


FIGURE 3.1.2-7, GROUND ILLUMINATION

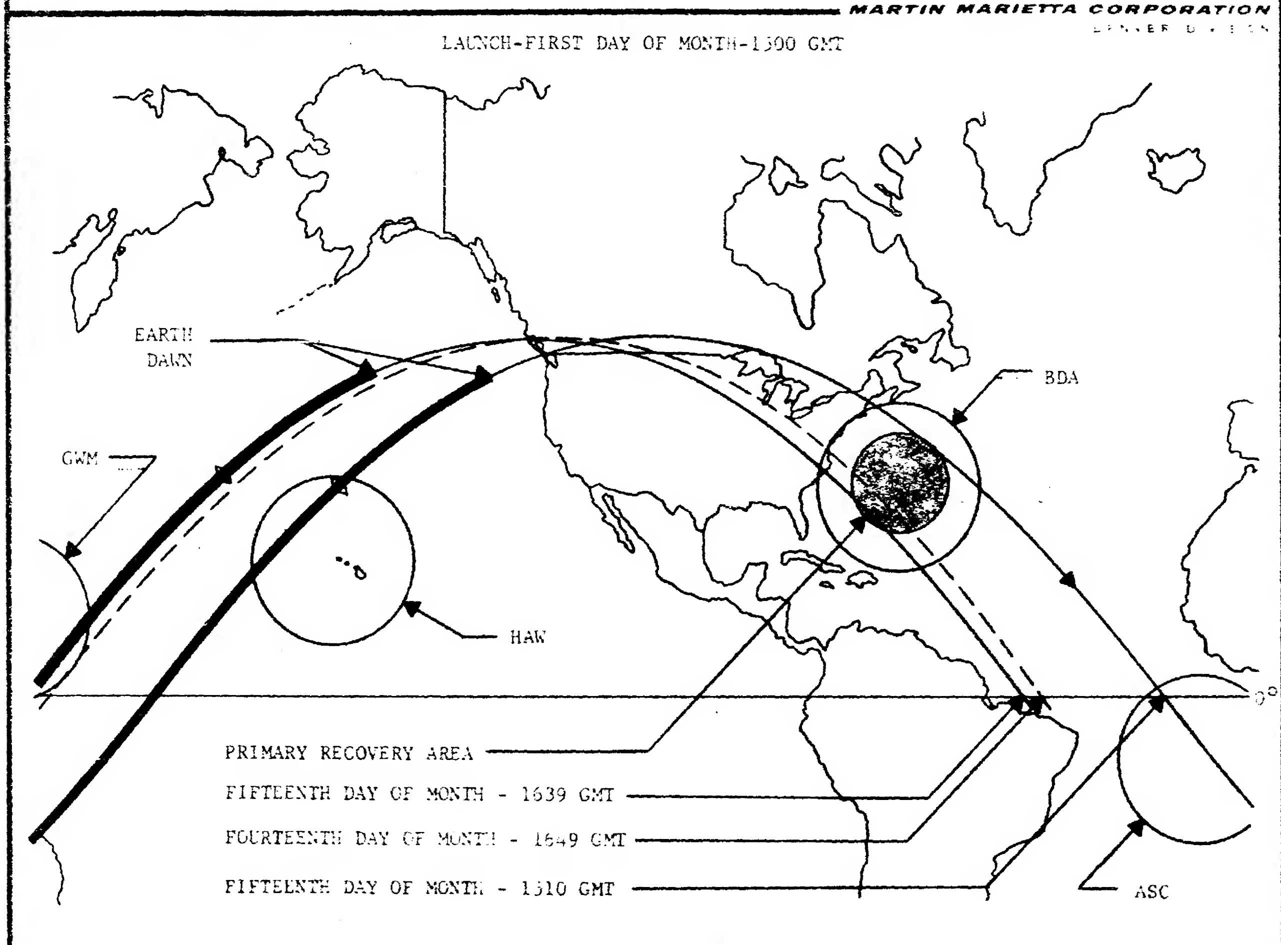


FIGURE 3.1.2.-8, DAYLIGHT RECOVERY AND COMMUNICATION

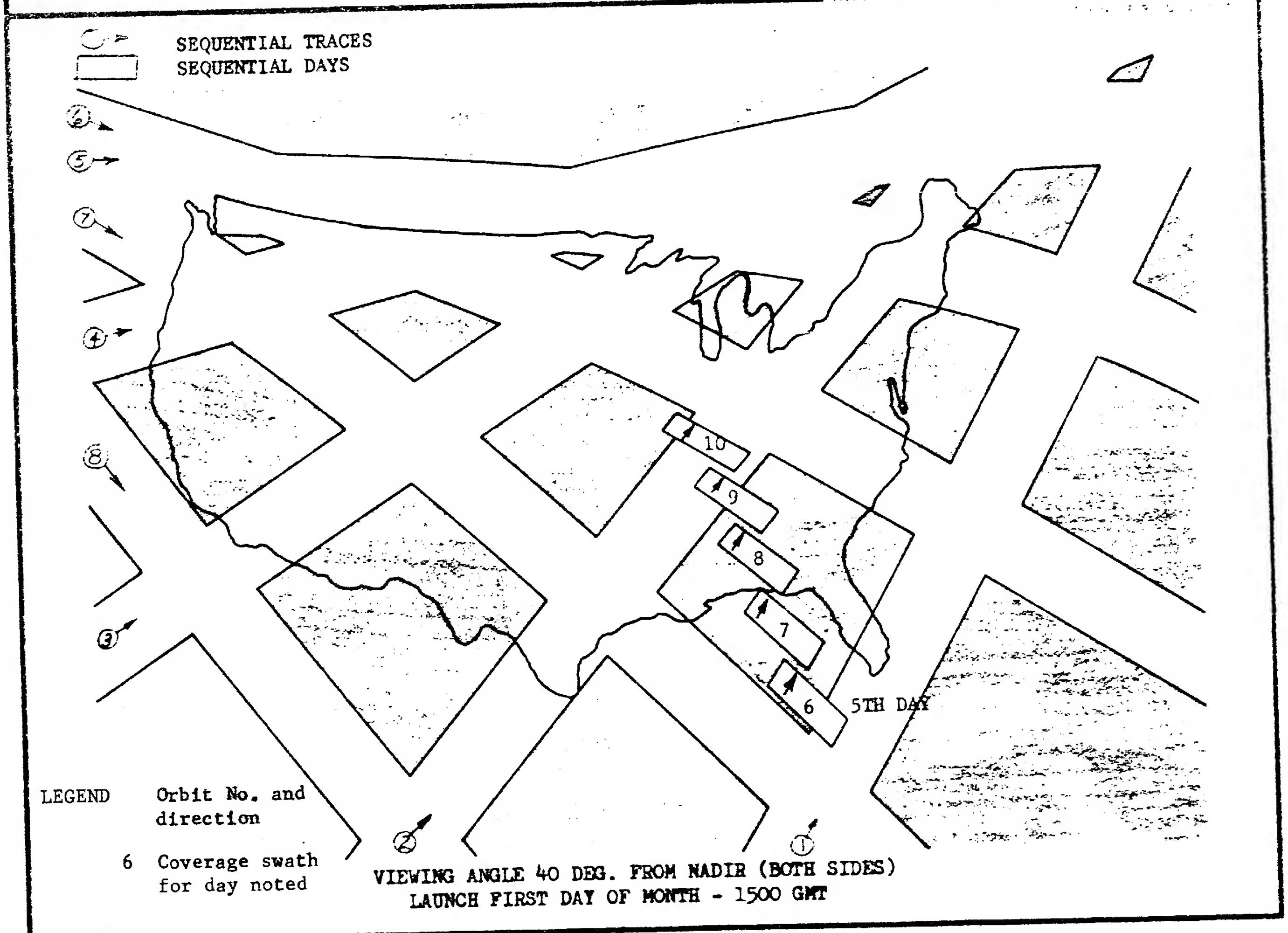


FIGURE 3.1.2-9 GROUND TRACES

3.1.3 Mission Integration

3.1.3.1 Baseline - Baseline mission ground rules and the candiate experiment list were defined by NASA-MSC. MMC's task has been to (1) perform overall carrier configuration and support subsystem design, and (2) perform mission definition and experiment/crew/mission integration tasks required to determine an allocation of available resources which would best accommodate all experiments.

In Paragraph 3.1.2, the basic study ground rules and constraints are expanded into a mission profile. This mission profile presents orbit histories, overstation times and overtarget times which define the available task periods for orbital operations. This part of the report will assign crew tasks and experiments to the available times and present an efficient time utilization. Future efforts will be directed to updating and optimization of the integration timeline.

3.1.3.2 14-Day Timeline - Figure 2.3-1 presented the overall mission timeline as evolved to date. It includes gross activity periods and reflects allocation of mission time to the various experiments.

The standard applications days selected were those which afforded a maximum of Continental United States overpasses with best lighting. Other experiments were worked around those days in such

3.1.3.2 (Continued)

a way as to minimize carrier entries by the flight crew and to integrate the total crew work cycle. Biological considerations associated with S015 and T004 are reflected in early mission scheduling of those experiments. It should also be noted that a crew rest day with minimal experiment activity is scheduled. Also, the day prior to reentry is reserved for data retrieval, storage and entry preps. Additional discussion is provided in PR29-46, Mission Timelines. Crew considerations are discussed in Paragraph 2.2.5.

Continuing effort is required to optimize the presented timeline. For example, detailed timelines for each 24 hour period must be prepared to evaluate MSFN loading, individual crewmen loading and consumable depletion. Those evaluations could lead to significant changes in the mission plan as herein presented. Additional trade studies/decisions are required in cases where individual experiment requests are not fully satisfied. Also, all mainline Apollo CSM crew tasks must be studied to ensure no conflict of work loadings, and RCS quad thermal histories evaluated to determine the requirements for periodic roll maneuvers.

3.1.3.3 Typical Day Timeline - Figure 2.3-2 presented the next detailed level of task timeline. The mission day depicted is typical of standard applications days and is representative of the mission.

Future iterations will reflect results of those evaluations discussed in the preceding paragraph. Other changes may result as definition of experiment requirements are finalized and iterated with overall mission capability. For example, a decrease in experiment pointing accuracy requirements or use of horizon scanners would reduce the frequency of IMU alignments.

Refer to PR29-46, Mission Timelines, for additional details.

3.1.3.4 Crew Impact - The 14-day timeline was prepared to achieve a simultaneous sleep cycle as nearly as possible consistent with the experiment and housekeeping operations.

Concentration of data taking over the Continental United States facilitates an 8-10 hour workday for all three crewmen during applications experiment days. Support of S016, however, requires one crewman's participation over longer periods on eight days. No more than two crewmen are actively involved in experiment activities at any one time with the third being free for normal CSM monitor/control.

3.1.3.5 Experiment Impact - A preliminary gross mission plan, depicted by the timelines, shows the extent of exercise of each experiment, and resulting demands for crew participation and CSM support (primarily pointing and tracking). A tabulation of percent accomplishment of individual experiment requests was presented in Tables 2.5-I and 2.5-II. The purpose of this discussion is to present results of a review of the timelines conducted to determine overall experiment/mission compatibility. The specific objectives of this review were to determine if any single experiment is overly demanding of mission resources over a 14-day mission, and to propose a compatible experiment list for a shorter duration mission.

For the full 14-day mission, a few experiments appear to place excessive demands on available resources (crew time, RCS, mission complexity, etc) as follows:

- S016 - The Trapped Paricle Asymmetry experiment imposes the following delta to on-orbit operations:

  25 additional maneuvers

  38 hours additional attitude hold

  long crew work days (15 to 16 hours overall), and staggered sleep cycles on 8 days.

3.1.3.5 (Continued)

- D009, T002 - The Simple Navigation and Manual Sightings experiments are highly demanding of crew time to be suited to a multi-purpose, short duration mission. (Approximately 8 work days total requested.) Timelines presented in this report reflect allocation of two full experiment days (nearly 1/5 of the available experiment time on a 14 day mission) in satisfying 100% of the D009 requirements and 15% of the T002 requirements

- S039, S040 - The Day/Night and Dielectric Tape Camera require S-Band data transmission capability. Data from the two cannot be played back simultaneously, thus requiring separate ground station readouts for each experiments target overpass. Also, a CM located CRT is desired for operation of S039.

- T003, S015, D017, T004 - The Bioscience experiments are included in the preliminary timelines with support periods integrated with other experiment activities. Such scheduling may complicate crew activities to the point of compromising other experiment objectives.

For a 14-day mission, deletion of S016, T002, and D009 could result in approaching the 100% level for accomplishment of the Astronomy experiment objectives, and an increase in accomplishment of S048 objectives while preserving the percent accomplishment of all other experiments.

Deletion of the bioscience and uncategorized experiments would, at first look, enable reasonable accomplishment of the Applications "A," Earth Resources, and Astronomy experiment groups with a shorter mission. For example, deletion from the 14-day mission of days allocated to T002, D009, Rest, and one applications day would result in a reduction of percentage accomplishment of the Applications "A" and Earth Resources experiments by approximately 20% and would preserve the Astronomy accomplishment.

3.1.3.6 Modular Mission and Contingency Plan - Successful accomplishment of the Flight 1A mission is in part dependent upon flexibility in gross mission definition and in detailed mission planning. On-orbit contingencies will necessitate real time mission redesign at the detailed level. Report PR29-13, Modular Mission and Contingency Planning Study, documents planning efforts aimed at providing flexibility required for that task. The objectives of that study were to (1) identify an approach to mission definition and detailed planning which readily interfaces with mainline Apollo and provides maximum contingency flexibility and (2) identify possible contingency situations with recommended alternatives.

The modular mission planning approach currently being implemented by MSC, NAA, and MMC is discussed in the above referenced report. Selected contingencies with recommended alternatives are discussed and a list of general ground rules included. The following paragraphs summarize that report.

- Building Block Concept - Adequate reaction to contingency situations is dependent upon flexibility in real time mission planning redesign. That flexibility can be attained through preparation and utilization of mission planning building blocks. Specifically, overall mission timelines should reflect phasing of grouped activities in such a way as to permit resequencing of major groups. Detailed timelines for each group, or for unique tasks, prepared as stand-alone sequences, can then be applied as appropriate without rewrite of a complete mission detailed sequence. Such timelines are being prepared to assist NASA in mission planning and are included in other sections of this report. Mission Modular Data Book building blocks, containing such things as detailed procedures, consumables required, constraints, and prerequisites for unique tasks will complete the data input as required for both initial modular mission planning, and real time on orbit planning and redesign.

3.1.3.6 (Continued)

- Gross Mission Alternatives - Only those contingencies which would degrade the overall mission capability from the baseline are included in the referenced study and summarized below.

  a. Late changes in boost payload capability will necessitate either a decrease in planned orbital altitude or attainable inclination or physical removal of entire experiments.

  b. Minor launch date changes will necessitate only small changes in optimum launch time of day, whereas significant date changes could result, even with optimum launch time of day, in a decrease in data yield due to degraded lighting conditions.

  c. Launch window contingencies of up to two hours will be accommodated by real time updating through mission scheduling flexibility.

- Payload Alternatives - In the event of failure to deliver or unacceptability of a given experiment, two alternatives exist; (1) substitute an equivalent experiment,or (2) fly a dummy. The The degree of equivalence required will increase as final systems test dates approach. Dummy payloads (identical in mass properties and mechanical interface) should be available for all experiments in the event of a late contingency.

- Experiment Scheduling Alternatives - On Orbit -

  a. Support subsystem failures which result in total failure to support an individual or block of experiments will result in elimination of those experiments from the mission plan and a rescheduling of all others to optimize remaining time.

3.1.3.6 (Continued)

b. Support subsystem failures which result in partial inability to support an individual or block of experiments will, in most cases, result in a decrease of time allocated to those experiments. (Obtain limited real time for sensor/concept qualification.)

c. Any failure which could jeopardize crew safety will result in termination of experiment activities and early reentry.

d. Anticipated decrease in mission duration should result in reallocation of experiment time to prevent total elimination of individual experiments.

- General Ground Rules - Additional contingency ground rules recommended for the AAP-1A mission are tabulated in PR29-13.

3.1.4 Flight Operations Support

3.1.4.1 Summary of Activities - Flight Operations support activities during the report period have been primarily focused on preparation for specific tasks to be accomplished during subsequent contract periods. Analyses of experiment support requirements, mission profiles, carrier/spacecraft and MSFN data handling capabilities, experiment mission compatibility, documentation support requirements and data management/correlation flow have been accomplished.

A modular mission planning approach has been defined (Paragraphs 3.1.3.6 and 3.1.4.4) and preliminary contingency plans prepared (Paragraph 3.1.3.6). Purpose, format and content of a Mission Modular Data Book to support that approach are presented in Paragraph 3.1.4.4. Also included are the identification of AAP-1A peculiar building block required.

3.1.4.2 Planning Sequence - Support Documentation - Initial flight operations support documentation will consist of inputs to NASA developed

3.1.4.2 (Continued)

Mission Operations Plan and preparation of AAP-1A Mission Modular Data Book. Those efforts are discussed in later paragraphs. A block diagram of MMC operations and evaluation plans and inputs to subsequent MSC documentation is shown in Figure 3.1.4-1. Time prior-to-launch for completion dates are also shown.

3.1.4.3 Mission Operations Plan - The Mission Operations Plan will identify mission activities and requirements, and experiment objectives for the AAP-1A flight. MMC will support NASA preparation of the MOP with inputs in the following areas:

a. Mission Plan - mission objectives, description, constraints, and experiment and carrier description;

b. KSC, MSFN and Truth-Site Support Requirements - launch pad, remote site, and ground truth-site real-time flight-support activities including communications and tracking;

c. Flight Crew Support Requirements, Flight Control Support Requirements, Recovery Support Requirements - unique carrier/experiment procedural requirements, interfaces, constraints, data flow, monitoring/control, MSFN, recovery, and ground truth-site requirements;

d. Training and Simulation - mission-dependent training requirements for individual flight crew members, flight controllers, contractor integration personnel, MSFN, recovery, and ground support personnel, principal investigators, experiment contractors, and recovery team members;

e. Personnel Requirements - integrating contractor personnel required to support NASA mission flight operations and evaluation activities;

f. Operation Documentation Development Plan - functional flow, overview, and sequencing of mission documentation.

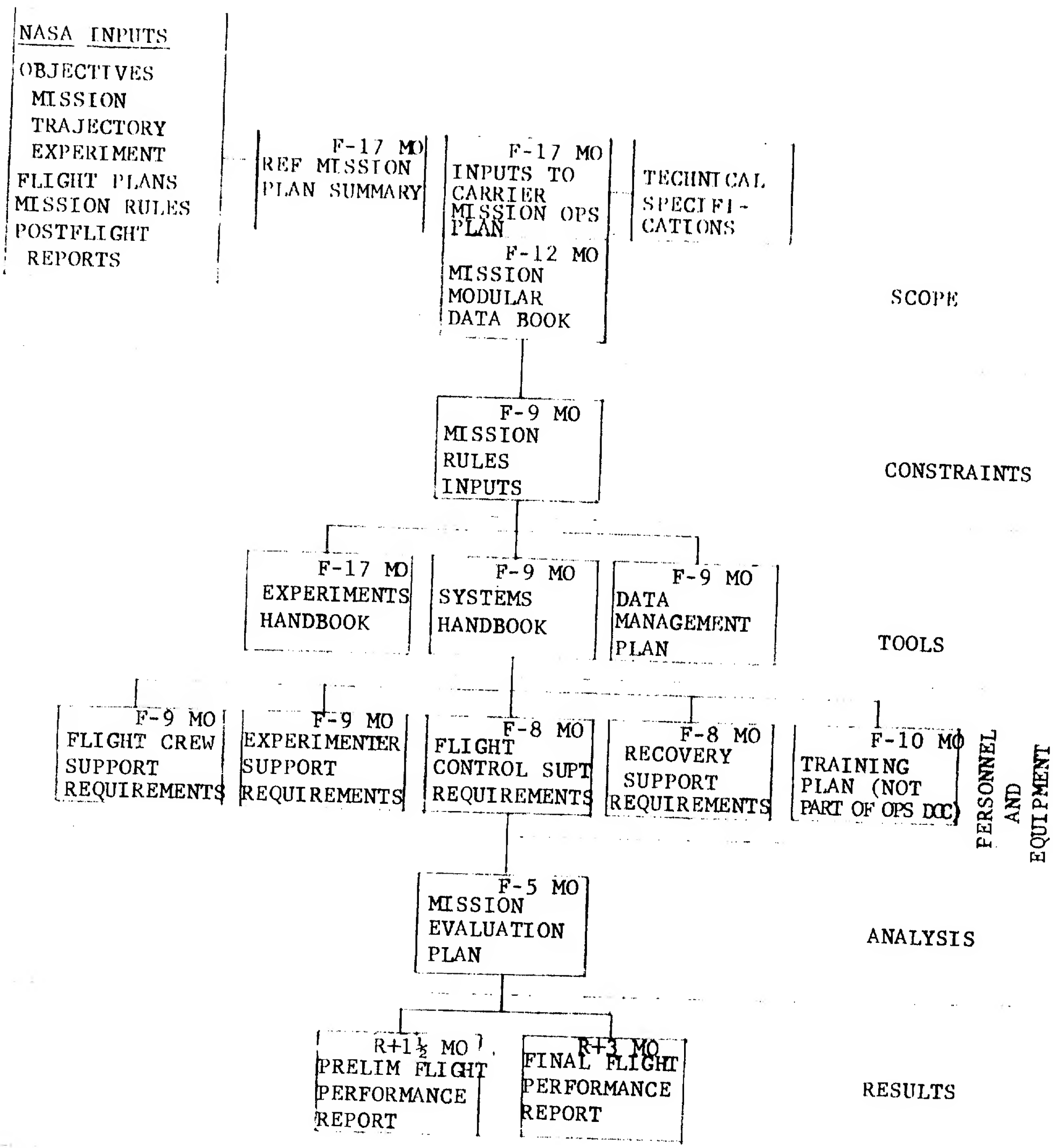


FIGURE 3.1.4-1
Operations and Evaluation Documentation Block Diagram

3.1.4.3 (Continued)

Overall scope and level of detail for individual areas will be reviewed with NASA-MSC prior to preparation.

Additional support to NASA's Mission Operations Plan preparation will be provided through preparation of a Data Management Plan and Mission Modular Data Book. The DMP will be prepared to identify total data flow including developmental testing, and experiment/subsystem data requirements (qualification, acceptance and flight), P.I. data correlation requirements, real-time and postflight data management, and the sequence and interactions of the experiment, tracking orientation, and crew data. Data management flow is shown in Figure 3.1.4-2.

3.1.4.4 Mission Modular Data Book - This document will provide operational information on the capabilities and limitations of the combined CSM, experiment carrier, and crew. The information will be provided for use in general mission planning and for real time mission redesign. This document will augment, not replace, North American Aviations Mission Modular Data Book for Block II Earth Orbital Missions. (See PR29-13, Modular Mission and Contingency Planning Study) for the assumed roles of NAA and MMC in preparation of a complete modular mission data package). The following outline and summary of contents define the document to be prepared:

a. Introduction - Purpose and scope of the overall MMDB and content summaries of all sections will be included. The building block format will be presented as well as a summary chart of all building blocks.

b. Carrier/Experiment Constraints - Unique carrier/experiment constraints which do not readily fit into building blocks or sections on electrical power and communications will be included.

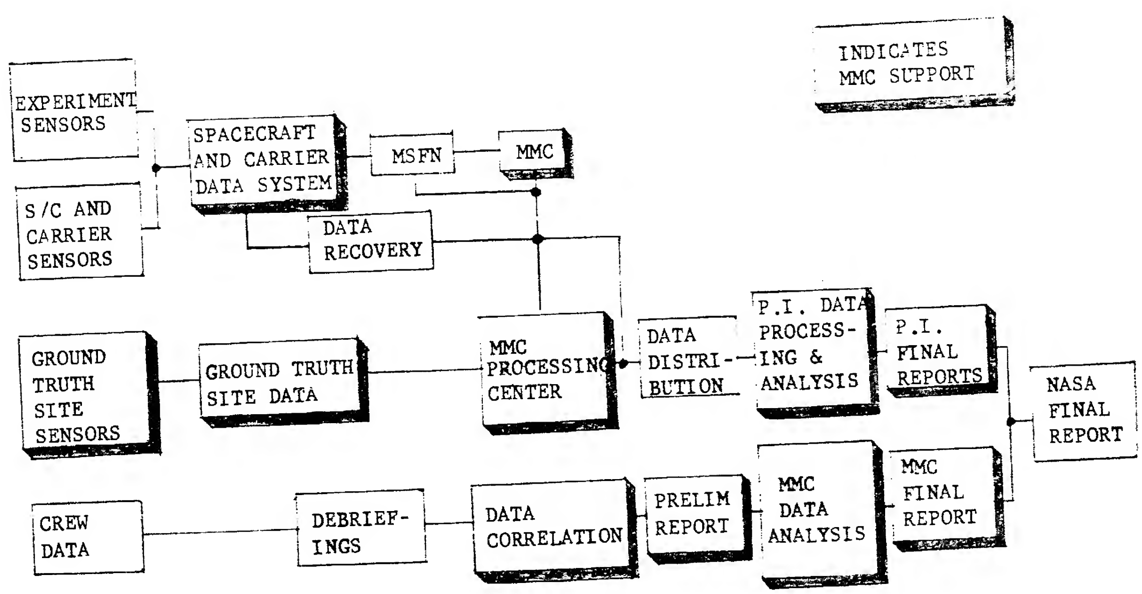


FIGURE 3.1.4-2

Flight Data Management/Correlation Diagram

3.1.4.4 (Continued)

c. Electrical Power - Data related to the operational mission characteristics of the carrier electrical power subsystem will be included. A master list of AC and DC power requirements of all mission peculiar equipments and experiments will be presented with and indication of power source - carrier or CSM.

d. Communications - A general description of the mission operational capability of the carrier communications subsystem, and detailed characteristics of each communications mode will be provided.

e. Building Blocks - PR21-13, Modular Mission and Contingency Planning Study, includes a tabulation of building blocks to be provided.

f. Test Objective Accomplishment Data - Data as required for visibility over test objective accomplishment while real-time mission redesign is being performed will be included.

The preceding outline parallels the content of North American Aviation's Mission Modular Data Book. This similarity will minimize confusion associated with real time utilization of the two data sources.

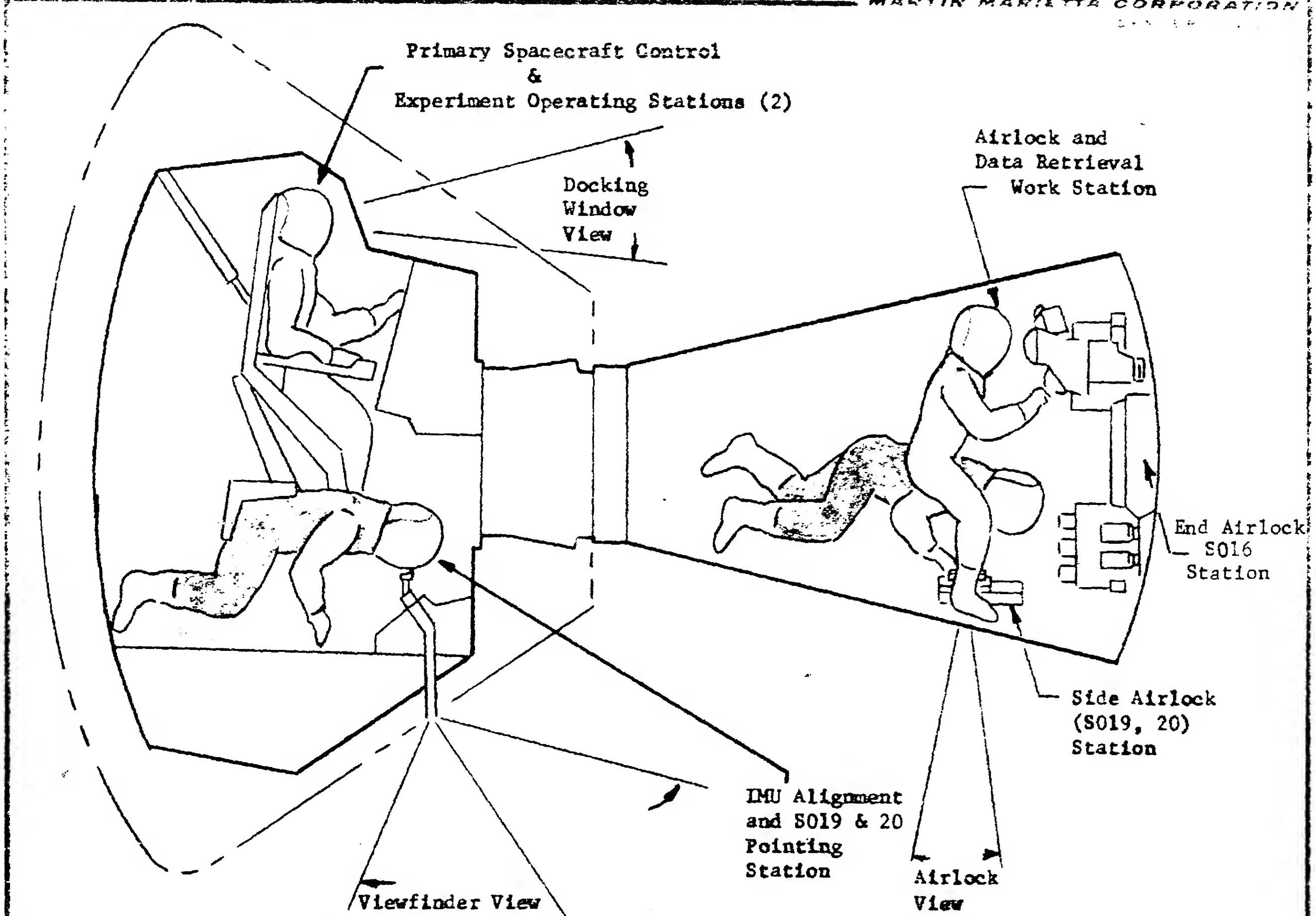
3.2 Crew Integration

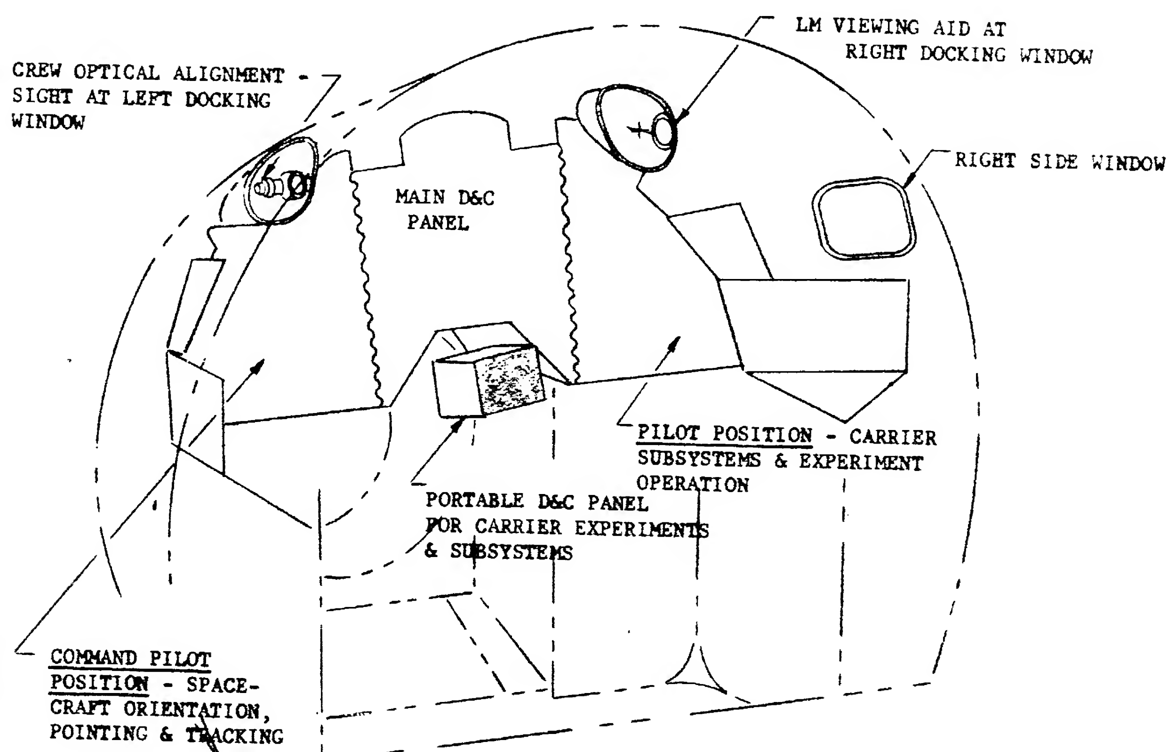
3.2.1 Summary - The crew integration activity for the two month study effort encompassed: identification of the crew role in supporting experiment operations; determination of the constraints and requirements imposed on the system as a result of crew participation; definition of design criteria for the carrier and crew equipment required for the crew when operating in the carrier; and identification of crew/equipment interfaces and critical tasks for which further detailed evaluation will be required. A summary review of training/trainers and a CM stowage management evaluation were also conducted. The criteria generated from this study was incorporated into the candidate carrier, experiment and subsystem configurations. The preliminary mission timelines reflect the considerations and constraints imposed by the crew, subsystems and experiments.

3.2.2 Intravehicular Activities (IVA)

3.2.2.1 The Command Module Crew Work Stations - The standard Block II Command Module crew work stations, shown in Figure 3.2.2-1, include the primary experiment control from the pilot's couch (right seat) using a portable display and control panel. This panel will be carried in the carrier during boost and relocated to temporary mounting brackets in the lower cutout area above the center couch during orbital flight, as shown in Figure 3.2.2-2. Details on the control and display panel design and interaction with the T004/S017 panel appear in Paragraph 4.1.4 and in PR29-33, Display and Control Studies. The right docking window provides direct viewing on the line of sight of the carrier mounted experiments.

Spacecraft flight and attitude control is provided by the Command Pilot (left seat) who also utilizes the left docking window for viewing sensor target areas. A Kollsmann pointing and tracking aid was evaluated which greatly increases the field of view. The center mounted portable D&C panel, Figure 3.2.2-3 may also be monitored and controlled by the Command Pilot (left seat). An auxiliary


Primary Spacecraft Control
&
Experiment Operating Stations (2)
Docking
Window
View
Airlock and
Data Retrieval
Work Station
End Airlock
S016
Station
Side Airlock
(S019, 20)
Station
IMU Alignment
and S019 & 20
Pointing
Station
Airlock
View
Viewfinder View



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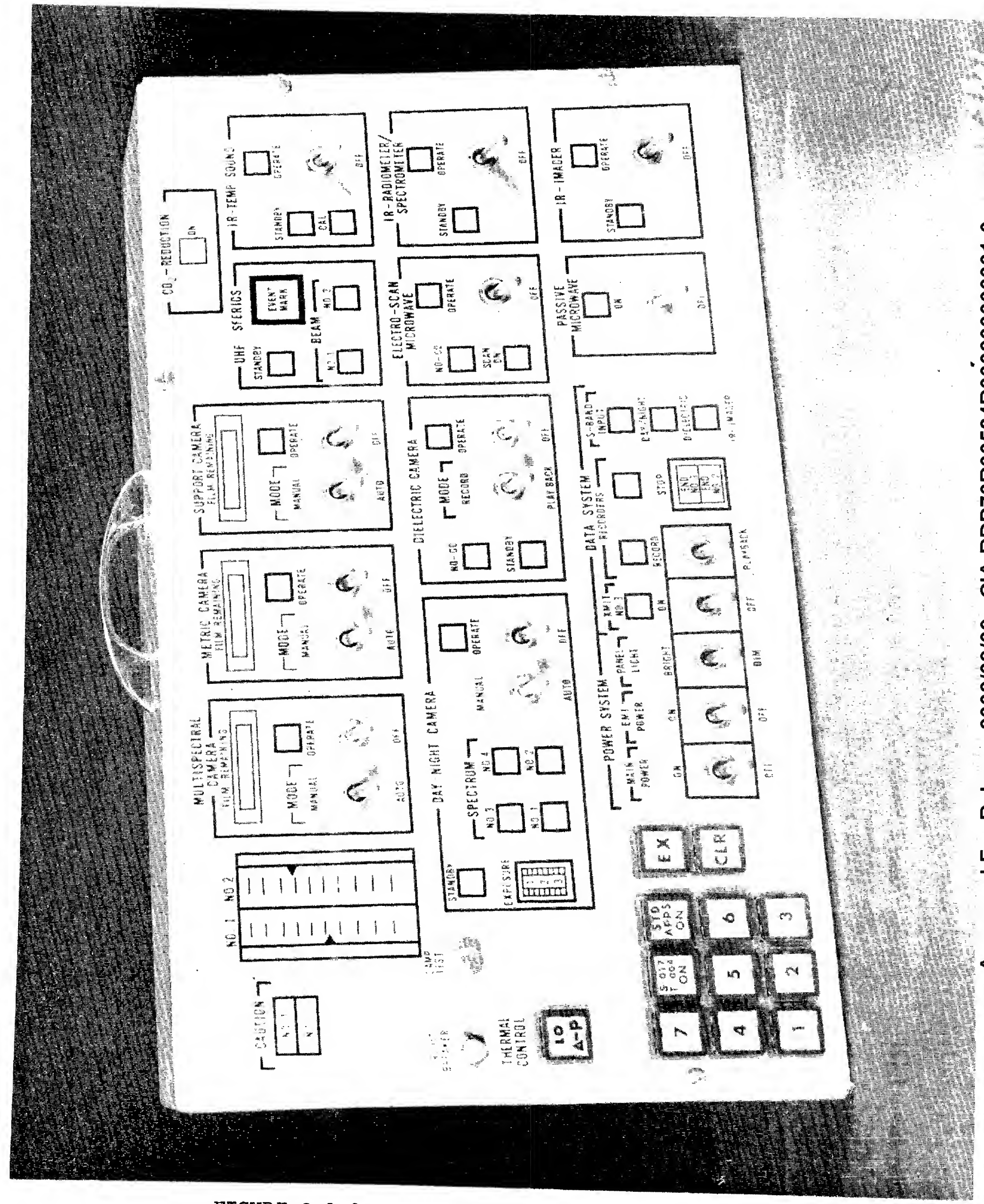

FIGURE 3.2.2-3, PORTABLE DISPLAY AND CONTROL (D&C) PANEL

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3.2.2.1 (Continued)

experiment pointing station is located at the G&N station in the Lower Equipment Bay (LEB) which is used for pointing and tracking sensor targets for the side airlock mounted experiments S019 and 20, this position can be seen in Figure 3.2.2-1.

Preliminary evaluation of these stations by Martin personnel has been made by checking the locations and positions in CM mockups at both MSC and at NAA. Additional considerations affecting the crew station D&C location may be found in PR29-43, Window Visibility Study, PR29-10, Spacecraft Orientation, and PR29-11, Crew Worksite Considerations.

3.2.2.2 Carrier Crew Work Stations - The carrier work stations were configured so at least one suited crewman could perform all experiment manipulating, data retrieval, and operations at both the end and side scientific airlock while concurrent activities by the other two crewmen occurred either in the CM couches or at the navigation viewfinder station in the (LEB). Although shirt sleeve operations in the carrier pressure vessel are preferred, the study baseline used a soft suited crewman using CM supplied oxygen through a lengthened closed loop suit umbilical including communication and biomedical monitoring. Design for a pressurized suit and PLSS was initially used for sizing the interior work areas. Use of the unmodified Mainline Apollo crew equipment including the ILC A7L pressure suit is planned. In addition crew and data package and, stowage restraints and crew and equipment translational tethers were evaluated. Internal illumination, stowage canisters for retrieved data, voice communications, work site restraints, translational aids for the crewmen, data cassettes, and expendable equipment were evaluated and discussed in PR29-14, Crew Equipment and Carrier Illumination.

The timeline analysis also resulted in a preliminary definition of carrier entry requirements summarized in Figure 3.2.2-4.

1. DOCK AND PLUG IN SLA ELECTRIC CONNECTOR - 1ST. DAY

2. STOW PROBE AND DROGUE, TRANSFER D&C TO CM, INSTALL S016 IN DOME AIRLOCK AND EXTEND, DISCONNECT SLA PLUG, CONNECT D&C ELECTRIC PLUGS, THRU D&C CIRCUIT BREAKER ON - 1ST DAY.

*3. INSTALL S020 IN WALL AIRLOCK AND OPERATE, REMOVE S020 AND INSTALL S019 - 2ND DAY.

4. CHANGE FILM ON 6 E06-4 CAMERAS - 4th DAY.

*5. BORESIGHT S019 WITH G&N SEXTANT AND OPERATE, REMOVE S020 AND INSTALL S018 - 6TH DAY.

6. CHANGE FILM ON 6 E06-4 CAMERAS, REMOVE S018 AND INSTALL S017, TRANSFER T002 AND D009 TO CM - 8TH DAY.

*7. TRANSFER T002 & D009 TO CARRIER, TRANSFER EMULSIONS, FILM, AND S019 AND S020 TO CM, STOW D&C PANELS (INCL. S017 AND FROG), PROBE AND DROGUE ASSAYS, AND CM EXPENDABLES (i.e., LiOH CANISTERS) IN CARRIER, OPEN D&C CIRCUIT BREAKER AND DISCONNECT PLUGS AT TUNNEL - 9TH DAY.

* WILL REQUIRE 2 ENTRIES - 1 MORNING, 1 AFTERNOON: MAY LEAVE HATCH OPEN BETWEEN THESE ENTRIES.

FIGURE 3.2.2-4, CARRIER ENTRIES

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3.2.2.2 (Continued)

The carrier work stations as shown in Figure 3.2.2-1 include the wall (side) airlock, dome airlock and the several camera experiments which require film retrieval and operation. Figure 3.2.2-5 shows a 1/10 scale model of the carrier with a transparent pressure vessel and crewman in position at the side airlock in his soft suit. These areas are not configured at this time but will be analyzed, mocked up in the full scale carrier crew station mockup shown in Figure 3.2.2-6 and tested in 1-G with pressure suited subjects. Phase D work in neutral buoyancy facilities to verify work station configurations, fastener and retrieval cassette/ crew interfaces, crew timelines and operational procedures are discussed in PR29-15, Phase D Simulation Plan.

3.2.2.3 Crew Visibility - The AAP-1A experiments require crew visibility, not only of the earth nadir target areas where data is being taken, but forward along the ground track to permit minor spacecraft maneuvering for target acquisition prior to over-pass. The baseline configuration for the carrier/ CM placed the primary crew observation station inside the CM and the study identified the viewing areas projected on the earth surface available from the CM forward and side windows and the scanning telescope at the LEB navigation station. Direct earth viewing by both crewmen in the left and right couches was emphasized without auxiliary systems to enhance the field of view.

The fields of view for the CM left docking (forward) and left side windows were plotted on an earth projection using the baseline AAP-1A altitude of 140 nautical miles, Figure 3.2.2-7. The flight orientation is nose down with the CM X axis aligned with local vertical and the heads of the crewmen directed forward along the velocity vector -Z axis. Viewing envelopes through the forward docking window were evaluated with the eyes of the crewmen located in two positions, determined by the couch adjustments. These were the boost and reentry, and docking positions.

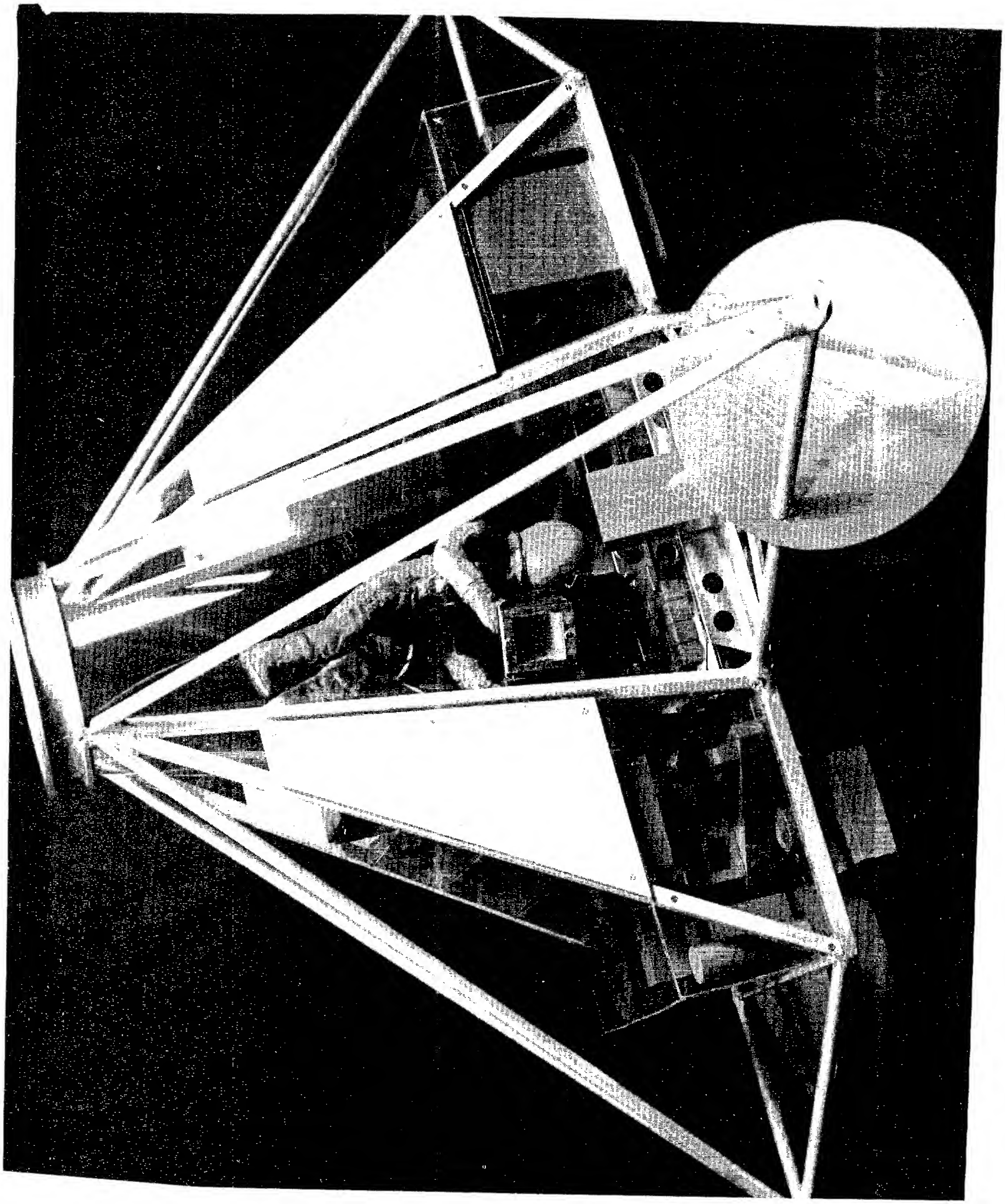


FIGURE 3.2.2-5, SUITED CREWMAN AT SIDE AIRLOCK
(1/10 SCALE MODEL)

FIGURE 3.2.2-6, SUITED SUBJECT IN
(FULL SCALE MOCKUP)

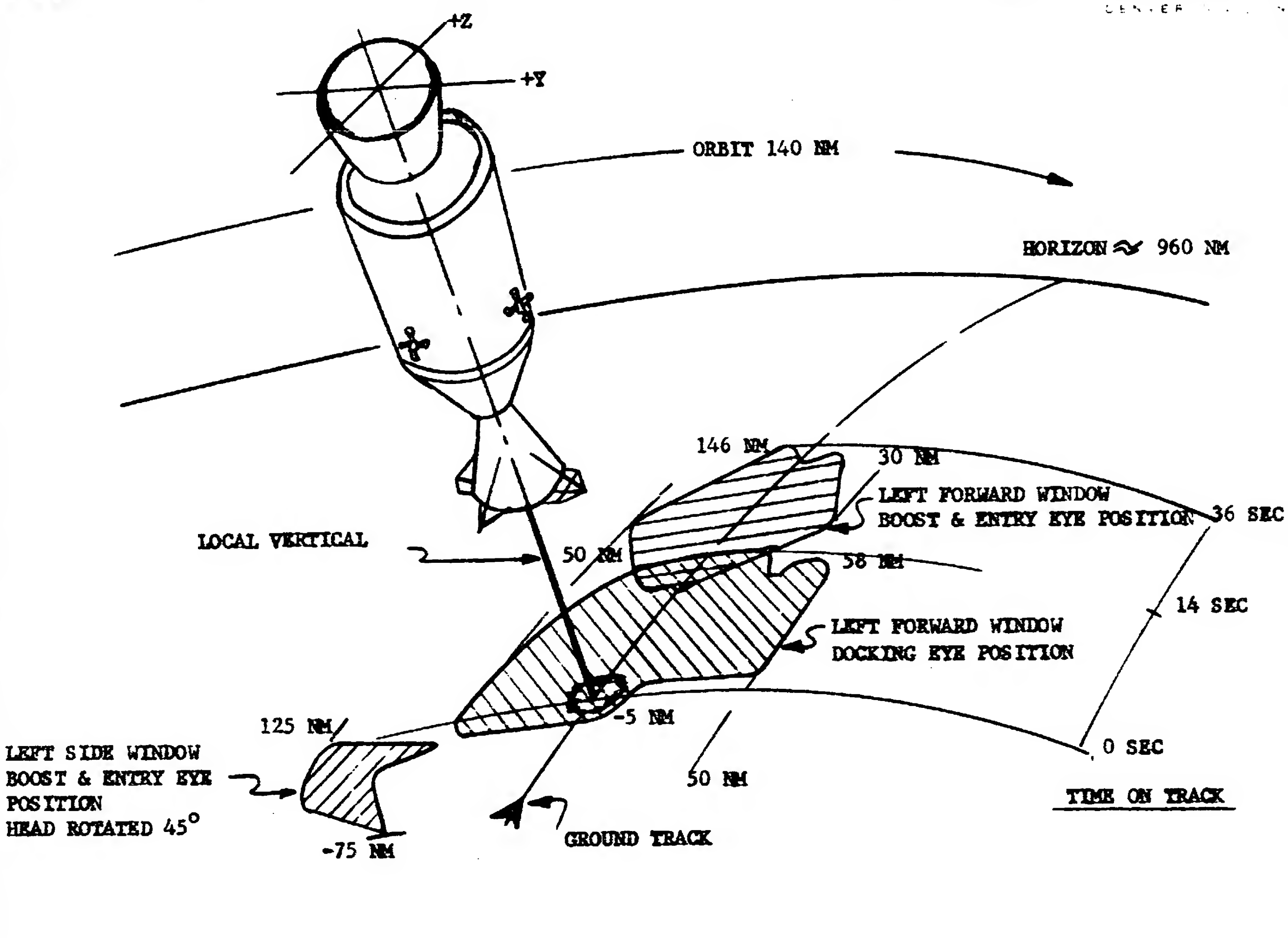


FIGURE 3.2.2-7, VISION: VISIBILITY

3.2.2.3 (Continued)

A 50th percentile crewman was assumed as the test subject.

The earth projections show that the nose down orientation provides pilot viewing through the docking window on nadir as well as forward target areas without auxiliary viewing devices. The crewman is in a normal, restrained body position in the couch. Additional study and testing will be conducted to determine the maximum viewing envelope available when the pilot is allowed limited translation of his head and upper torso in all directions above the vehicle's X axis. Viewing augmentation by the incorporation of mirrors similar to those in the Block II CM was also investigated.

The CM window fields of view and crew positioning relative to the windows was obtained from NAA test report No. CSU-402076, Evaluation of Command Module (CM) Docking and Side Window Field of View, dated 31 May 1966. Window locations were obtained from NAA Block II drawings for spacecraft 101. The viewfinder study encompasses a brief review of the existing PGNS and a survey of candidate systems which MMC has evaluated during this study effort. This study is described in PR29-43, Window Visibility. Report No. PR29-12, Pointing and Stabilization Study, contains a more detailed analysis of the candidate hardware and spacecraft interface.

3.2.3 Crew Equipment

3.2.3.1 Space Suit Assembly - This study effort has assumed usage of the Apollo A7L pressure suit as configured for mainline Apollo. Carrier operations would require the entire A7L ensemble (excepting the thermal meteoroid garment, helment visor, boots and gloves) be donned and sealed and pressurized to the CM/carrier pressure (nominal 5 psia) by means of the extended CM umbilicals. The crewman working in the carrier would derive O_2 support from the right hand couch umbilical. For the baseline carrier configuration, operations

3.2.3.1 (Continued)

at the forward airlock and experiment station (truss) would require lengthening this umbilical from 119 to 144 inches. During the study a full scale mockup was constructed to evaluate compatibility with a suited crewman and determine the umbilical length for O_2, communications and biomed support. Figure 3.2.3-1 depicts the test subject at the experiment truss located at forward end of the carrier. In the left foreground the right couch umbilical connector mockup is shown.

3.2.3.2 Crew and Equipment Tethering - Four categories of tethers are necessary for carrier operations. These are crew worksite restraints, data package worksite restraints, data package stowage restraints, and crew and equipment translational tethering.

The crew worksite restraints would include three assemblies - the carrier tether attachment, the crew attachment harness and the foot restraint assembly. At each worksite, connectors would be provided to interface the torso mounted assembly. The tether members may either be attached to the carrier connectors when not in use and transferred from one worksite to another by the crewman or each worksite may be provided a separate set of tethers so length adjustment by the crewman could be eliminated. Time required for transfer from one station to another could also be reduced.

Foot restraint is recommended at each worksite. The "Dutch shoes" used during EVA at the Gemini adapter section on GT-12, or a toe bar are considered as candidates for this sytem. The data package worksite restraints would consist of tethers mounted near the worksite on the carrier or directly to the crewman. This tether would temporarily secure the data package while the crewman is preparing to emplace it or transfer it to the translational restraint assembly.

Provisions for separate cassette protective canisters and securing the experiment components within the CM prior to reentry will be studied during the

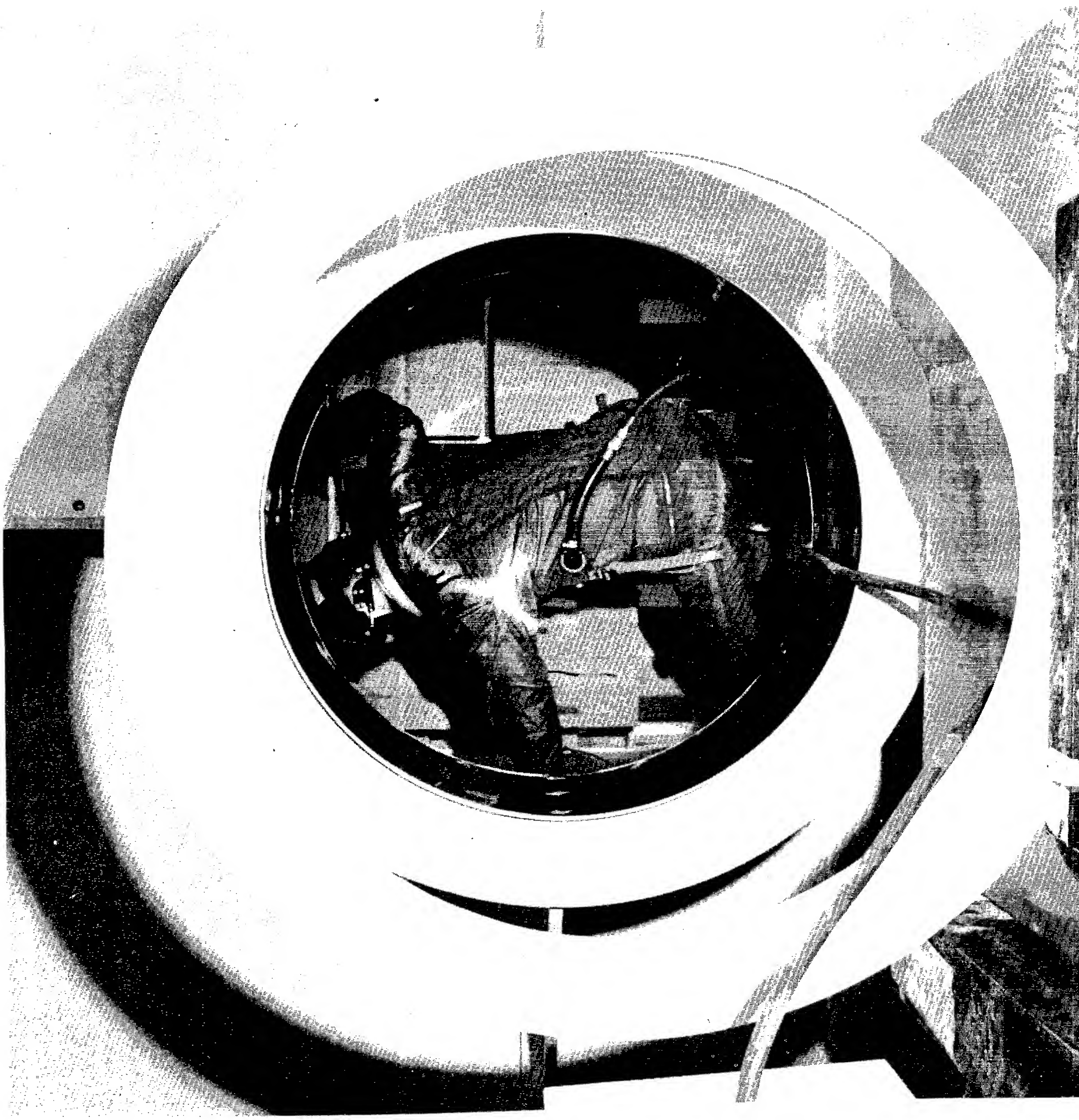


FIGURE 3.2.3-1, SUBJECT AT END AIRLOCK POSITION WITH SUIT UMBILICAL FROM CM (FULL SCALE MOCKUP)

3.2.3.2 (Continued)

the overall tethering/restraint study and the stowage management analysis. A crew and equipment translational device is considered necessary if more than one component would be transferred between the CM and carrier per entry. Figure 3.2.3-2 shows one such device, a slotted rail system which MMC designed and tested during the NASA-MSC AEP (pallet) study. This configuration employed a swing-out extension which is manually deployed by the crewman. It has rectangular cross-section and is positioned 2-1/2 inches from the mounting surface. Slots were incorporated on both sides for the retention of a U-shaped bracket attached to each data package. The crewman would translate along the rail, pushing the components ahead.

MMC will evaluate the following crew restraint systems for both shirt sleeve and suited operations as well as other candiate systems recommended by the NASA-MSC. The initial candidates include: Gemini 12 restraint, GE variable restraint, Dutch shoes, tension reel tether, tubular restraints, and rigidized anchor points.

3.2.3.3 Illumination - A preliminary investigation of carrier lighting requirements indicates that several carrier mounted lights, possibly incorporating directional adjustment, would eliminate the encumbrance of crew-mounted portable lighting. The overall illumination level in the carrier should approximate 20 to 30 foot candles. A non-reflective interior finish will be used on the carrier pressure vessel. Localized lighting will be required for shadowed areas at the experiment truss, and the side airlock.

Carrier tunnel lighting will be necessary for probe and drogue operations, and electrical plug retrieval and connection. Control of the lights will be provided as near the carrier tunnel as possible to facilitate local crew actuation. PR29-14 Crew Equipment and Carrier Illumination Requirements summarizes the study efforts in the above areas.

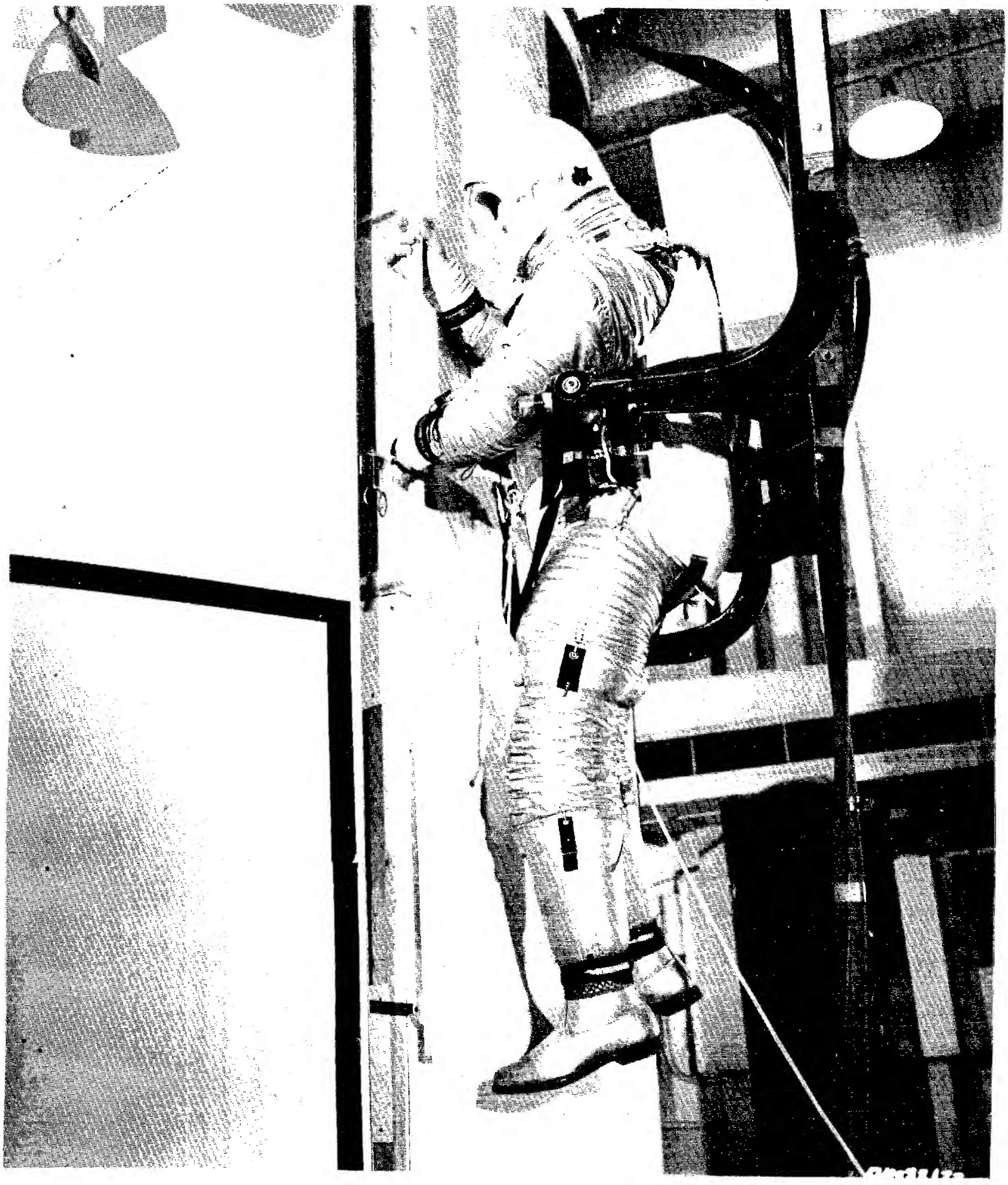


FIGURE 3.2.3-2, SUITED SUBJECT USING TRANSLATIONAL RAIL IN MMC SIMULATION

3.2.3.4 Communications - The CM right couch cobra cable from the CM voice communication and biomed instrumentation provides a link from the CM bulkhead connectors to the crewman while he is in the carrier. For the carrier baseline configuration this umbilical must also be lengthened to 144 inches to permit crew access to the experiment truss. This change is necessary whether the crewman is operating in a suited or shirt sleeve mode unless separate hardline connectors and headsets are provided which would utilize CM interface pins.

3.2.4 Crew Task Evaluation - A detailed crew task evaluation was conducted for the preparation of the fourth 24-hour day timeline and total baseline mission timeline. This data is presented in Paragraph 3.1.3 and in more detail in PR29-46, Mission Timelines.

3.2.4.1 Crew Duty Cycle Considerations - Table 3.2.4-I lists the requirements and constraints which regulate the time available to the crew personnel, subsystem and experiment activities.

TABLE 3.2.4-I CREW TIMELINE REQUIREMENTS

FUNCTION	TIME ALLOCATION/DAY
Sleep	*8 hours/crewman
Eat	*3-1hr periods/crewman
Exercise	3-10 min. periods/crewman
Crew Housekeeping	1-1/2 hours/crewman
Systems Housekeeping	*2 hours/crewman

* Simultaneous participation by all three crewmen preferred.

Time allocation for such critical tasks as suit donning and doffing, IMU alignment, and probe and drogue removal are covered in detail in the Mission Timelines document referenced above.

3.2.4.1 (Continued)

A crew workload analysis will also be conducted for critical carrier operations to ensure crew/task/equipment compatibility. Particular emphasis will be given to suited operations (if required) where metabolic rates may be marginally high.

As it is received from the NASA-MSC, mainline Apollo timeline data generated for missions preceding AAP-1A will be incorporated into the timeline where applicable. Measured time requirements for these and newly defined tasks will be incorporated in the total mission timeline.

3.2.4.2 Simulation - The Phase D simulation program will include detailed evaluation of the following tasks:

- D&C Panel retrieval and CM mounting
- D&C electrical connection and circuit breaker actuation
- Crew transfer to carrier work stations
- Attachment and disconnect of crew and component tethers
- Data package retrieval and installation
- Data package translation between carrier and CM
- Experiment operation with D&C
- Data package stowage in CM
- Expendable equipment stowage in carrier
- Target acquisition and RCS propellant management scientific airlock, experimentation installation operation and retrieval

This effort has been surveyed in PR29-15 Phase D Simulation Plan.

3.2.4.2 (Continued)

TABLE 3.2.4-II
EXPERIMENT FUNCTIONAL CAPABILITIES

Experiment Function	Operating Mode	
	Manual	Automatic
Orient to Local Vertical		
Select optimum earth tar.	X	
Ascertain target condition within specification	X	
Track or scan earth target	X	
Select Star field		X
Track stellar target	X	
Checkout Experiment	X	X
Select alternate experiment (due to malfunction or out of tolerance target condition)	X	
Anotate Data	X	
Retrieve data packages	X	
Reschedule experiment sequencing	X	

Most of the baseline experiment grouping may only be conducted with a man-in-the-loop. Table 3.2.4-III contains a complete experiment listing and denotes not only those which require manned input for operation and/or data return, but also those which may have a higher probability of successfully meeting experimental requirements by utilization of the crew.

3.2.4.2 (Continued)

TABLE 3.2.4-III
EXPERIMENT/CREW REQUIRMENTS AND ENHANCEMENT

Experiment	Manned Requirement		Enhanced by Man	
	Operation	Data Return	Operation	Data Qual
E06-1		X		X
E06-4		X		X
E06-7		X		X
E06-9A & B				X
E06-11				
S039			X	
S040				
S043			X	
S044A				
S048			X	X
T002	X	X		
T003	X	X		
T004				
D008	X	X		
D009	X	X		
D017				
S015	X	X		
S016		X		
S017	X			
S018		X		
S019	X	X		
S020	X	X		

3.2.5 Crew Training/Trainers - Martin has recently performed initial training analyses for the scientific experiments under the MSFC AAP Integration contract. These experiments formerly identified for AAP Flights 1 through 4 were evaluated for crew proficiency requirements, commonality with other experiments, detailed experiment training requirements, and inflight task requirements. A training requirements summary was prepared, equipment and task commonality with similar experiments was evaluated and training equipment requirements including the Apollo Mission Simulator, neutral buoyancy trainers, six degree of freedon zero g suspension simulators and parts and components trainers were identified.

The list of experiments analyzed includes S016, S017, S018, S019 and S020, D017, T002, T003, T004 and the several hand held camera experiments S005, S006, S063 and S065 which are related to S042.

An indepth Flight Crew Training Study and A nalysis Report ED-2002-40, dated 21 March 1967, covering these and other AAP experiments was prepared. This data will serve as the initial input for the AAP-1A Training Program Development shown in Figure 3.2.5-1, and discussed in PR29-17 Phase D Training and Trainer Requirements.

These data will be combined with NASA Apollo and AAP inputs, related to the AAP-1A carrier/experiment configurations and updated for the development Phase D training products. Similar evaluations will be made for earth resources, meteorology, solar and stellar experiments.

Training equipment initially identified for AAP-1A mission support includes a Display and Control package installed in the MSC/KSC Apollo Mission Simulators in the flight position shown in Figure 3.2.5-2 for combined crew training in pointing, tracking and experiment operations. An IVA carrier simulator/trainer used for crew training in experiment and airlock operations is required and will be used in neutral buoyancy and perhaps KC-135 preflight training. Stowage management exercises at NAA prior to the flight will require all CM boost and reentry packages for crew familiarization. Special training in the NAA scientific

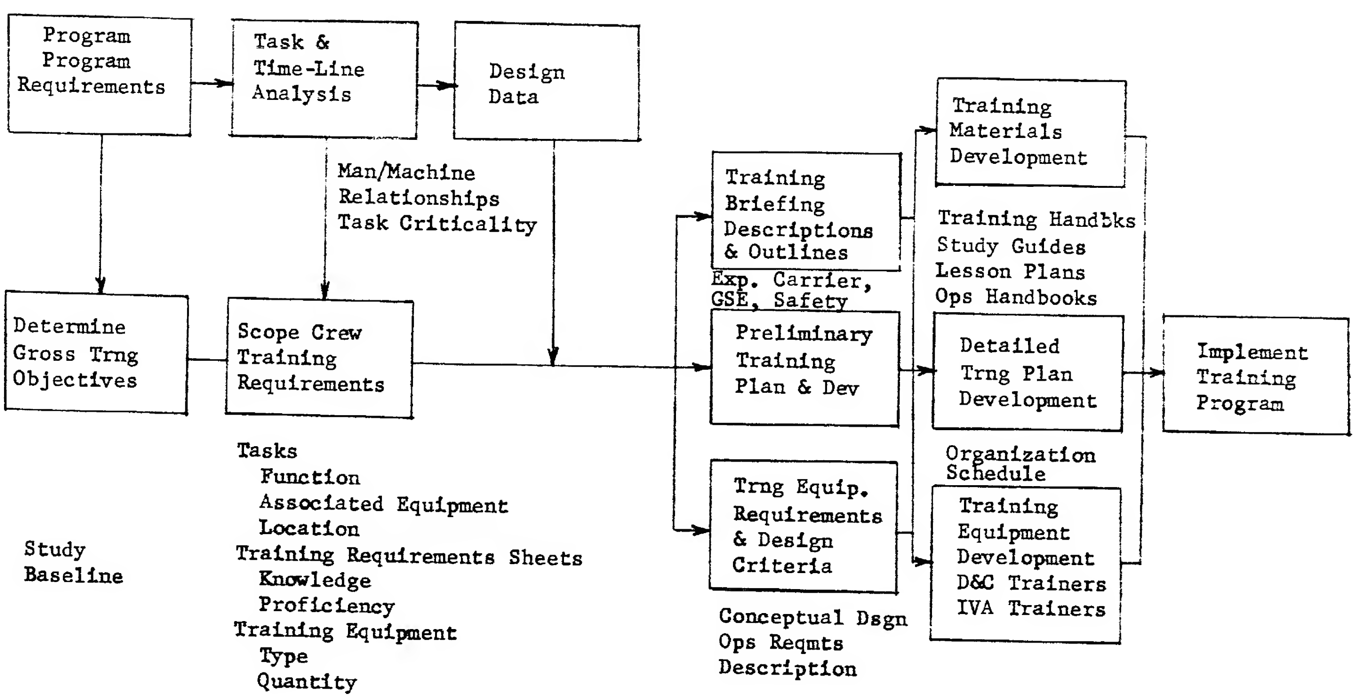


FIGURE 3.2.5-1, Training Program Development Flow

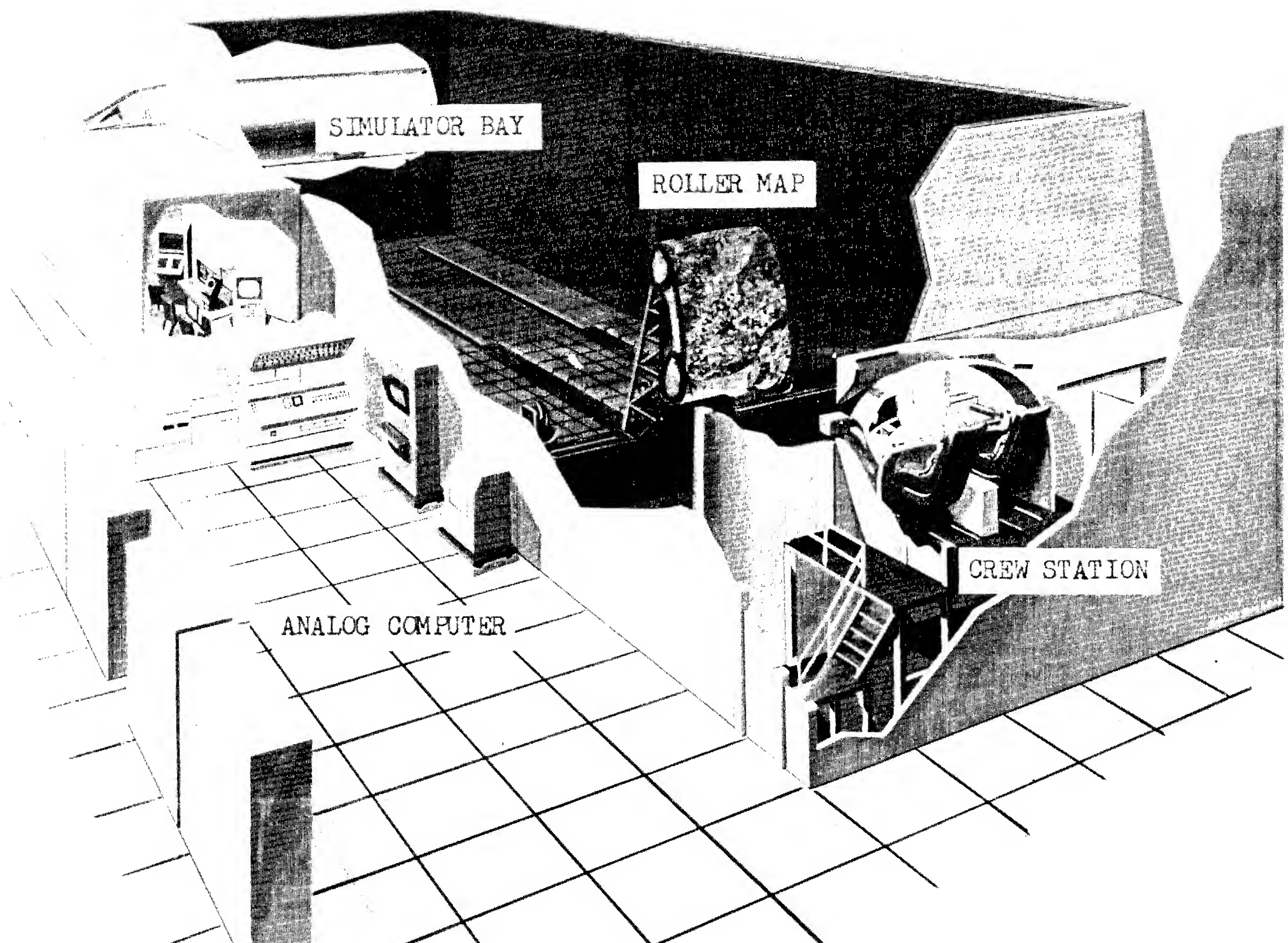


FIGURE 3.2.5-2 DENVER SPACE OPERATIONAL ...

3.2.5 (Continued)

airlocks, manual sextants for T002, Hasselblad and other experiment camera cassettes, handling of the S016 + 18 emulsions.

Martin will determine the potential use of the Denver Space Operations Simulator shown in Figure 3.2.5-2 to provide early crew experience in pointing and tracking. This facility will enable us to confirm the proposed mission/experimental crew operations (prior to availability of the MSC-AMS for the AAP-1A flight) using an existing two seat cockpit, and viewing a moving earth map which is controlled by hybrid computer system. The out-the-window view incorporates an infinite starfield and superimposed variable magnification TV display of non-earth targets that can provide both solar and stellar targets. This facility will provide early crew operations verification in case the NASA-MSC procedures trainers are not available for AAP-1A mission usage.

3.2.6 Command Module Stowage - Various experiments require either complete experiment module or data module stowage in the CM during boost, orbit or reentry. The specific stowage requirements of each experiment were studied and tabulated in Figure 3.2.6-1. The AAP-1A mission requires 219.9 lbs and 6.6 ft^3 including an additional 25% weight and 50% volume allowance for protective packaging. The stowage capability of the CM was evaluated, utilizing a stowage study conducted by NAA in May 1966, and updated by recent CM drawings for spacecraft 101 obtained from NAA. Locations within the CM for specific modules during the various phases of the mission were determined, based on the experiment volume and weight versus the allowable volume and weight for each proposed location. Figure 3.2.6-2 illustrates the proposed location of each experiment requiring stowage in the CM. The shaded areas represent unable reentry volume available for stowage after the AAP-1A experiment data (black areas) are located. From a total volume and weight standpoint, the CM stowage capability greatly exceeds the Mission 1A experiments stowage requirements. Specific details are reported in PR29-16, the CM Stowage Management Trade Study.

EXP. NUMBER	EQPT. STOWED	MISSION PHASE	ITEM WT.	ITEM VOL.	ITEM DIMENSIONS	PROPOSED LOCATION	LOC. LTR.	ALLOW. WT.	AVAIL. VOL.	ADDITIONAL INFORMATION
S019	Comp.Exp.	2	43	1750	8x11½x19	Replace Rock Box	F	61	2060	Original NAA/NASA Installation Proposal
S020	Comp.Exp.	2	35.2	1750	8x11½x19	Replace Rock Box	G	52	1645	Original NAA/NASA Installation Proposal
S015	Comp.Exp.	4	22	800	15½x6½x8	Replace TV Camera and Camera Mount	S	25	864	Original NAA/NASA Installation Proposal (S015 Only) Could not be used since the RRS now occupies that space
T003	Comp.Exp.	4	5.5	140	3.75x7.5x5.5	Avail.Locker Space, Aft Bulkhead	T	30	1000	
E06-1	Film Packs	2	20	1440	12x12x10	Avail. Space, Aft Bulkhead	T	150	7430	Revised NAA drawings show additional storage space on the aft bulkhead
E06-4	Film Packs (18 cassettes)	2	21.5	1152	4x4x4 (ea)					
E06-7	Film Packs	2	10	243	9x9x3					
D008	Elect/Act DSM.	4	2.5	90	7x4x3.18	Girth Ring, Forward surface, Avail. Space	Q	5	173	Original NAA/NASA Installation Proposal
D008	Pass. DSM	4	.5	10.6	6x1.5 (Dia)					
D008	Pass. DSM	4	.5	10.6	6x1.5 (Dia)	Upper inside surface, film & tape pkg.	W	-	-	
D008	Pass. DSM	4	.5	10.6	6x1.5 (Dia)	Outside rt. LiOH can, outside surface	T	25	4840	LiOH cans on Aft. Compt. Fl. against lower eqpt. bay. Original NASA/NAA installation proposal
D008	Pass. DSM	4	.5	10.6	6x1.5 (Dia)	Outside lt. LiOH can, outside surface				

FIGURE 3.2.6-1, CM MOUNTED EXPERIMENT/DATA/EQUIPMENT MODULES, STOWAGE STUDY

Plan No. PR29-8
Page 8

EXP. NUMBER	EQPT. STOWED	MISSION PHASE	ITEM WT.	ITEM VOL.	ITEM DIMENSIONS	PROPOSED LOCATION	LOC. LTR.	ALLOW. WT.	AVAIL. VOL.	ADDITIONAL INFORMATION
D008	Pass. DSM	4	.5	10.6	6x1.5 (Dia)	Avail. space @ X_c79, Y_c31.7 Z_c10.2	-	-	-	Mounted to existing brackétry
D009	Accessories	2	.1	4.2	7x6x.1	Avail. Stor. Space	B	3	173	
S016	Nuc. Emul.	2	8	63	3.5x5 (Dia)	Avail. Stor. Space	P	20	692	Original NAA/NASA installation was in the aft lower eqpt. bay. Specific intended area could not be located. Alternate location was chosen (S016).
S018	Collector Box	2	5.5	98.5	5.1x5.1x3.8	Avail. Stor. Space				Original NAA/NASA Installation was in the personal hygiene container. Since a storage area was available, the PHC was left undisturbed (S018).
T002	Accessories	2	.1	4.2	7x6x.1	Avail. Stor. Space	B	3	173	
A11	D&C Panel	3	-	-		Rock Box	F	61	2060	Storage area for periods of non-use of D&C panels, during orbit phase only.
S017	D&C Panel	3	25	1100	6.75x10.75 x6.25	Rock Box	G	52	1645	
-	Pressure Hatch	3	-	-		Strapped to aft portion on left hand eqpt. bay	S	-	-	Original NAA/NASA storage location.

FIGURE 3.2.6-1 CM MOUNTED EXPERIMENT/DATA/EQUIPMENT MODULES, STOWAGE STUDY

EXP. NUMBER	EQPT. STOWED	MISSION PHASE	ITEM WT.	ITEM VOL.	ITEM DIMENSIONS	PROPOSED LOCATION	LOC. LTR.	ALLOW. WT.	AVAIL. VOL.	ADDITIONAL INFORMATION
-	Probe & Drogue	1	-	-		Aft compartment Floor	T	-	-	Primary stowage in carrier. CM stowage would only be an alternate location.
	E06-4 Reload Film Packs, 12-Cassettes	1	15	768		Rock Box	G	-	-	

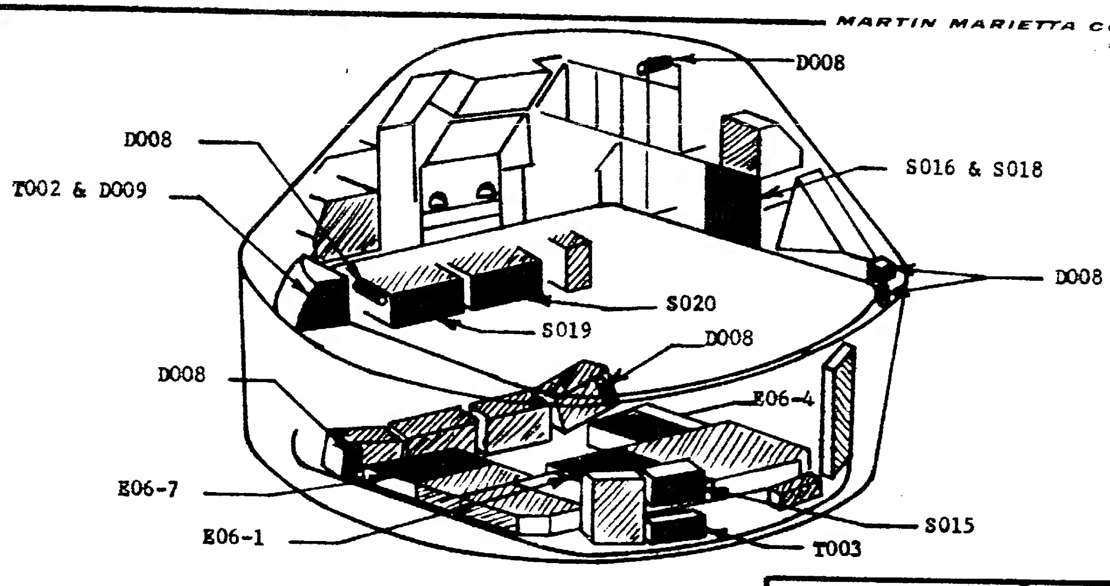
1 Alternate Location

2 Reentry Only

3 Orbit only

4 Boost, Orbit and Reentry

FIGURE 3.2.6-1, CM MOUNTED EXPERIMENT/DATA/EQUIPMENT MODULES, STOWAGE STUDY



	ORIGINAL NAA STOWAGE STUDY (5-5-66)		NAA STOWAGE CONFIGURATION DWG. #2743-116 (6-1-67)	
	WEIGHT (POUNDS)	VOLUME (Cubic Ft)	WEIGHT (POUNDS	VOLUME (Cubic Ft)
AVAILABLE STOWAGE WITHOUT BLOCK-II EQUIPMENT DELETION OR TRANSFER TO CARRIER	131	8.64	200	13
STOWAGE AVAILABLE AFTER EQUIPMENT TRANSFER TO CARRIER	392.5	18.35	560	26
STOWAGE AVAILABLE AFTER EQUIPMENT DELETION AND TRANSFER TO CARRIER	1066	38.25	930	33
MISSION 1-A STOWAGE REQUIREMENTS (REENTRY)	219.9	6.6	219.9	6.6

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FIGURE 3.2.6-2, COMMAND MODULE STOWAGE

4. SYSTEMS

This section describes the design for the carrier subsystems required to support the AAP-1A experiments.

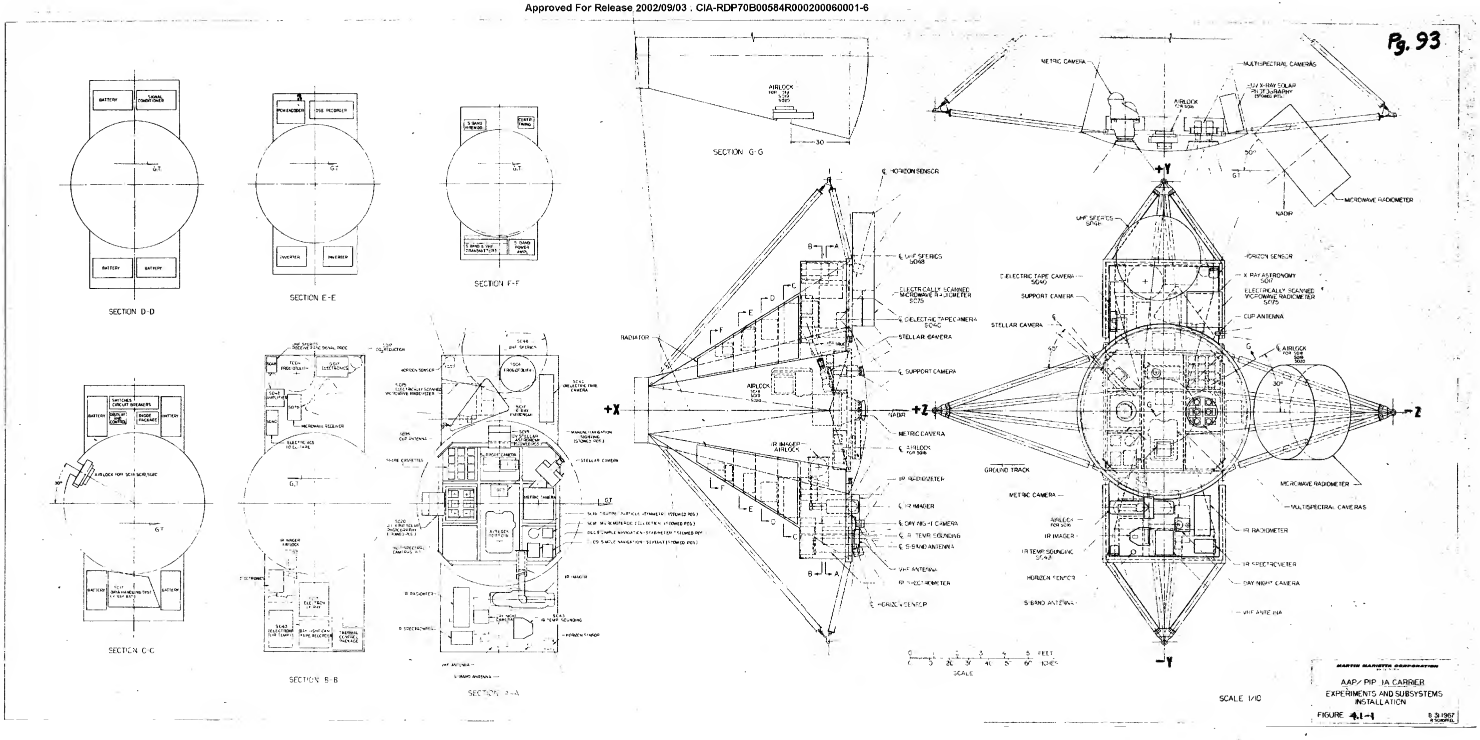
4.1 Carrier Configuration

The selected carrier configuration, shown in Figure 4.1-1, mounts the experiment sensors in an axial viewing (nose down) attitude. This configuration was derived primarily through three trade studies. PR29-10, "1A Spacecraft Orientation", selected an axial viewing attitude. In study PR29-7, "Carrier Configuration Trade Study", several candidate carriers were evaluated, with a selection of one pressurized and one unpressurized configuration being made. Finally, in PR29-8, "Carrier Pressurization Study," the pressurized carrier was selected as the baseline configuration for the AAP-1A carrier.

The pressurizeable portion of the carrier, called the pressure chamber assembly, is in the shape of a truncated circular cone expanding from the docking tunnel diameter to an 84 inch diameter at the removeable spherical segment aft closure. Four truss assemblies support the carrier in the SLA, and provide the necessary SLA lateral support during the boost phase of flight.

The pressure chamber houses only those experiment components which require data retrieval via direct crew access. Adequate volume is provided for crew IVA and for stowage of various items of equipment during launch and subsequent orbital activities. The balance of the experiment components are mounted on two earthfacing platforms located on the (+y) and (-y) sides of the spherical aft closure (ref. CSM coordinate system). In addition, one large light-weight antenna assembly is supported by the (+z) truss. The forward, or (-z), truss is left open to avoid crew viewing interference.

Support subsystem components are mounted on two equipment racks each supported by two longerons and two experiment platform support members. The thermal control system radiators are attached to the sides of the equipment support racks.


Pg. 93
SECTION D-D
SECTION E-E
SECTION F-F
SECTION G-G
SECTION C-C
SECTION B-B
SECTION A-A
BATTERY
INVERTER
AIRLOCK
RADIATOR
METRIC CAMERA
MULTISPECTRAL CAMERAS
MICROWAVE RADIOMETER
NADIR
HORIZON SENSOR
STELLAR CAMERA
SUPPORT CAMERA
IR IMAGER
IR RADIOMETER
IR SPECTROMETER
DAY-NIGHT CAMERA
VHF ANTENNA
S-BAND ANTENNA
GROUND TRACK
+X
+Y
-Y
+Z
-Z
SCALE
SCALE 1/10
MARTIN MARIETTA CORPORATION
AAP/PIP 1A CARRIER
EXPERIMENTS AND SUBSYSTEMS
INSTALLATION
FIGURE 4.1-1

4.1 (continued)

The selected configuration incorporates provisions for growth of experiment and subsystem component sizes and weights. The experiment support frame, located in the pressure chamber, is capable of either mounting additional items or complete replacement. Since the aft closure is removeable, alternate closure structure with the appropriate viewing windows may also be used. In addition, the +Z axis truss (oriented aft along ground track in orbital attitude) may be replaced by a third Y axis truss with its equipment mounting rack capable of supporting additional components. This carrier configuration represents the most favorable combination of the following desireable features:

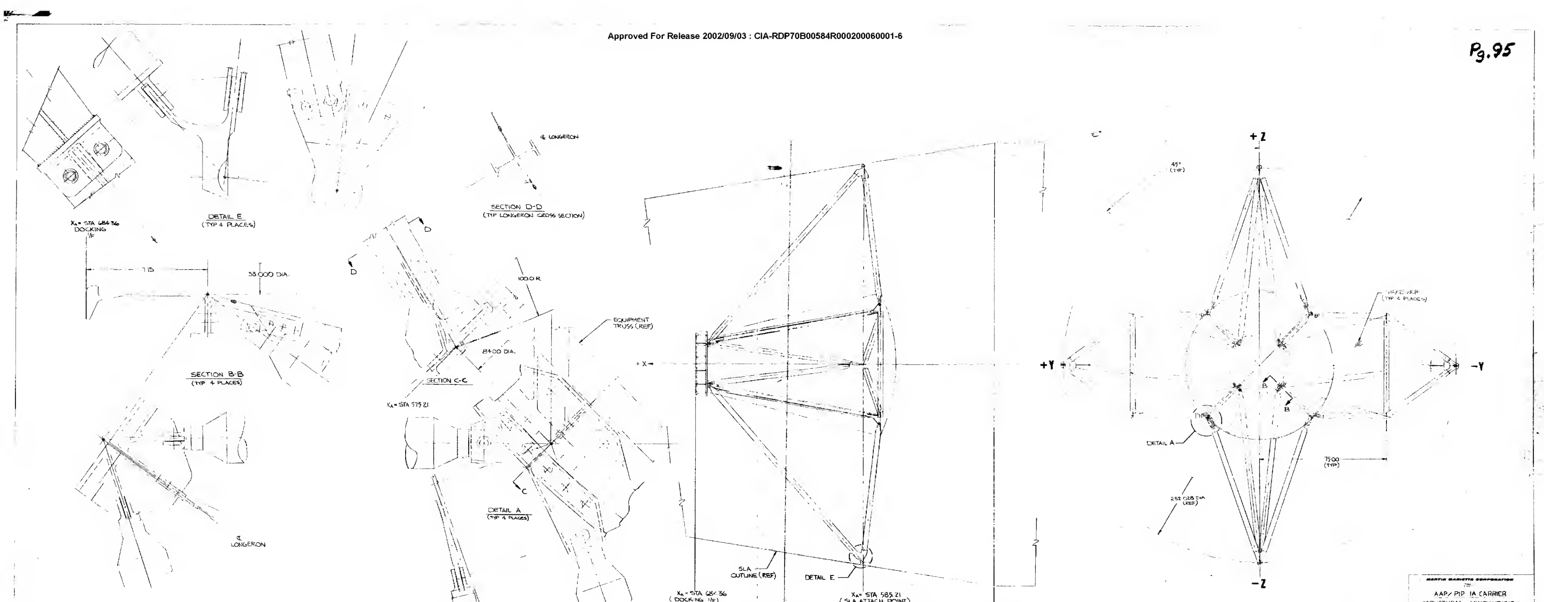
- IVA in a pressurized volume with the crewman suited but with no pressure differential across the suit affords maximum mobility and dexterity while providing the maximum of safety for the crewman.

- Location outside of the pressurized volume of all experiment and subsystem components not requiring direct crew access, minimizes sensor degradation which may be caused by viewing through windows, minimizes hazards associated with equipment operating in an oxygen atmosphere, allows the utilization of a relatively small volume which must be pressurized, and facilitates installation checkout and maintenance of components during assembly and on-pad operations.

- The axial viewing orientation provides good crew visibility from the CM along the ground track beneath the carrier and forward of it, and locates the experiment sensors so that the effect of CSM emitted contamination is minimized.

- The carrier design is straightforward, utilizing state-of-art material and fabrication methods which will minimize costs and the production problems during the tight AAP-1A development and fabrication schedule.

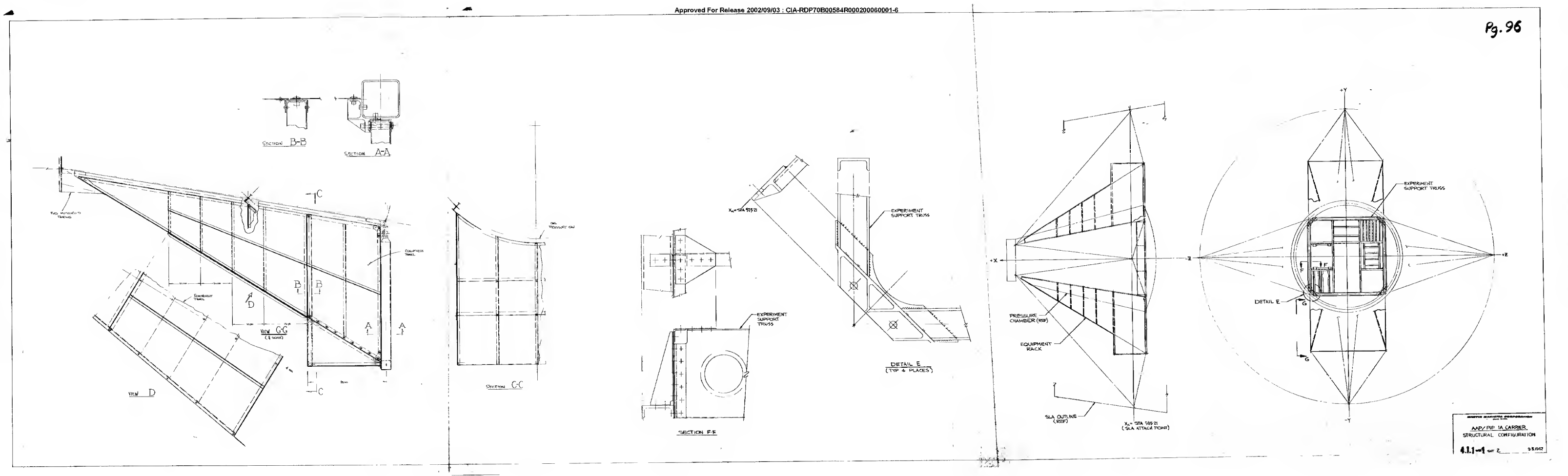
- Significant growth capability to accommodate additional experiment and subsystem components is inherent in the design.



MARTIN MARIETTA CORPORATION

AAP/PIP IA CARRIER
STRUCTURAL CONFIGURATION

FIGURE 4.1.1-1 SHT 1 9 5 1967



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4.1.1 Structures -

4.1.1.1 Structural Description - Figure 4.1.1-1 depicts the major structural features of the selected carrier, as described in PR29-37, "Structural Configuration Description". The pressure chamber is composed of two major sub-assemblies, the sidewall and aft closure structures. The conical sidewall sub-assembly is a welded structure made of 2219 aluminum alloy, consisting of four machined longerons welded to four .040 in. thick skin quarter panels. This sub-assembly is welded, at its small end, to the docking tunnel-kick frame assembly and, at its large end, to the aft closure bolting ring-kick frame to create the sidewall assembly. The docking interface and drogue support features of the docking tunnel are identical to the LM design. Truss attach fittings are bolted to the assembly at the junctures of the longerons with the kick frames. The bolts used to attach the fittings do not penetrate the pressure shell. The spherical segment aft closure is a spin-formed 2219 aluminum alloy shell, welded to a rough machined forged ring bolting flange with final machining of the flange and chemical machining of the shell to a thickness of .050 in. being accomplished after welding. An "O" ring is used as the pressure seal at the interface of the closure and the sidewall assembly.

The Z axis trusses (oriented fore and aft in orbital attitude) are each composed of four tubes. Adjustable rod ends are provided for attachment to the fittings located on the pressure chamber and fixed lugs are used for attachment of the tubes to the SLA attachment fittings. Secondary truss members are added to the truss located on the +Z axis to provide support for the microwave radiometer experiment antenna array.

In addition to supporting the carrier in the SLA and providing SLA lateral support, the Y axis trusses are designed to support the experiment mounting platforms. The equipment racks each consist of four shelves supported by triangular side panels which are riveted to the longeron, the experiment platform mounting frame, and the truss support member. Shelves are attached to the side panels by means of shelf support members. A removeable load carrying segmented trapezoidal cover completes the rack structure.

4.1.1.1 (continued)

This cover along with the side panels provides meteoroid protection for components located on the shelves, as well as for two quadrants of the pressure shell. The side panels provide support for the TCS radiator assemblies. A thin aluminum alloy meteoroid bumper, .016 in. thick, covers the two unshielded quadrants of the conical pressure chamber.

Provisions for pressure chamber wall penetrations such as windows, scientific airlocks, and wire bundle feed throughs are designed to minimize leakage. In general, frames for these penetrations will be machined to the proper configurations as separate parts and then butt welded into cutouts in the skin panels and aft closure.

The experiment support frame, located inside of the pressure chamber, supports several experiments in their operating locations and provides stowage locations for other experiments when they are not operating. This frame also provides direct load paths between the Y and Z axis truss attachments at the large end of the chamber.

IVA handholds and other crew maneuvering aids will be attached to the longerons which incorporate internal flanges designed for this purpose.

4.1.1.2 Installation of Experiments and Subsystems - Figure 4.1-1 shows the general arrangement of experiment and subsystem components in the selected carrier. (Refer to PR29-38, "Experiment and Subsystem Installation Report")

The basic ground rule established to guide the placement of experiment and subsystem components was that only those components requiring data retrieval via direct crew access should be located in the carrier's pressure chamber.

This dictated that the Metric Camera and Multi-Spectral camera experiments along with the experiment Support Camera should be mounted in the chamber. These cameras view their objectives through windows located in the pressure walls, and are mounted on the experiment support frame. The spare film cassettes for the Multi-Spectral Cameras are stored

4.1.1.2 (continued)

adjacent to the cameras. Experiments which are supported on the frame when they are not operating include D009, T002, S016, S018, S019 and S020.

Another experiment requiring crew access for data retrieval is the IR Imager. However, since the operation of this experiment requires a direct view of its objective without looking through a window, the experiment is located adjacent to the pressure chamber wall on one of the experiment mounting platforms. A film transport device is used to take exposed film through the chamber wall into a film cassette, located in an airlock.

In addition to these components, two NAA designed scientific airlocks are mounted on the pressure chamber. One airlock, to be used for deployment and retrieval of the S016 Nuclear Emulsion experiment, is mounted on the spherical segment closure. This location was chosen to permit the desired deployment orientation of the experiment. The other airlock is attached to the conical portion of the pressure chamber. The S018 Micrometeorite Collection, the S019 UV Stellar Astronomy and the S020 UV X-Ray Solar Astronomy experiments share time on this airlock. Location of the unit was chosen to satisfy viewing and orientation requirements of the experiments, to facilitate crewman ability to sight through viewers in two of the experiments, and to allow alignment with the G & N scope.

The remainder of the experiments with the exception of the microwave radiometer, which is supported by the +Z axis truss, are located on the two experiment support platforms which are attached to the +Y and -Y axes trusses. The locations of these experiments were chosen after considering preliminary sensor viewing requirements, the carrier c.g. location, and access for pre-launch installation, removal, adjustments and checkout. One component requiring special consideration is the Day-Night Camera. Since the image orthicon tube's major axis must not be colinear with the boost thrust vector, the camera must be mounted on a mechanism capable of supporting the camera during launch and then moving it to the operating attitude.

4.1.1.2 (continued)

The nadir viewing experiments will be accurately aligned on installation to be parallel with the carrier - CSM center-line. The carrier structure must provide a rigid platform to maintain this alignment through launch and orbital operations, the only significant loading is the internal pressure. This pressure load causes deflections in the aft pressure bulkhead, with possible adverse effects on window optical properties. Preliminary deflection studies indicate a maximum dome deflection at operating pressure of approximately 0.03 inches, with a rotation of 0.11 degrees, at the window locations. The dome deflection will have no effect on window optic properties; also, the window rotation is sufficiently small that negligible effect on optics is expected. However, further study is necessary in this area.

Subsystem components are located on the eight shelves which are provided on the two equipment racks. Factors influencing the locations of components on the shelves include sizes and required orientation of components, space available on shelves, carrier c.g. location, experiment temperatures, minimization of wire runs and fluid lines, and access for pre-launch installation, removal, adjustment and checkout of units.

The need for contamination control devices to prevent unacceptable degradation of sensor operation has been established for several of the experiments. Potential sources of contamination include the SLA separation system, RCS combustion products, and the meteoroid environment. Although the orientation of the carrier with nearly all experiment sensors looking away from the CSM minimizes the CSM emitted contaminant problem, contamination control is still considered necessary. The covers need not be gas tight, but must be capable of excluding relatively small particles. Thermal and meteoroid protection is provided integral with the covers. Since the pressure chamber mounted experiments look through windows, covers are provided to protect the windows during extended non-operating periods. These covers are positioned by electro-mechanical actuators located outside of the chamber. Since the possibility of actuator malfunction exists, a manual override is provided for actuating the covers. Pressure wall penetrations, as well as cost and weight, may be minimized by using one actuator to position several covers where this proves feasible.

4.1.1.2 (continued)

Experiments located on the unpressurized platforms will be protected with covers in a similar manner.

Passive thermal control for the entire carrier is provided by multi-layer insulation blankets attached to the exterior surfaces of the equipment racks and experiment mounting platforms, and to the aft closure and the two unshielded quadrants of the pressure chamber. Cutouts in the blankets are provided for sensor viewing where the insulated contamination control covers provide protection.

4.1.1.3 Structural Loads and Stress Analysis - The analysis summarized in this report represents the first iteration in the engineering design process. All primary structure was examined as well as key items of secondary structure. The member sizes developed at this stage will form the basis of the structural model used to develop more accurate loads. Results of computer analysis of the basic structure for boost, docking and lateral stiffness are shown as well as of the analysis of key details. Refer to PR29-25, "Stress Analysis Report", for further detail.

4.1.1.3.1 Loads and Materials -

a. *Inertia Loads - Boost Phase

Condition 1 - Stage I Burn Out
N_z = -6.92 g's limit (aft)
N_x = N_y = 0

Condition 2 - Post Release
N_z = -4.5 g's limit (aft)
N_x = 3.75 g's limit

Condition 3 - Post Release
N_z = -4.5 g's limit (aft)
N_y = 3.75 g's limit

b. Pressurization -

**Condition 4 - Operating pressure = 5.2 psid
Proof pressure = 9.5 psid
Ultimate pressure = 12.9 psid

*Includes a 1.5 dynamic amplification factor.
**Ref to Command Module Design Pressures

c. *Transposition Docking -

Condition 5 - Axial Load = 2,610# (Compression)
Lateral Load = 2,600#
Moment = 30,840 in-lb
(Limit Loads shown)

d. Lateral Stiffness -

Condition 6 - The carrier is required to furnish a minimum structural stiffness between diametrically opposed SLA hardpoints of 50,000 lb/in.

e. Factors of Safety - Table 4.1.1-I presents the factors of safety used for this study.

f. Materials - The basic structural material for the carrier is 2219 aluminum alloy. It was selected because of its favorable welding and strength characteristics. Other higher strength materials, e.g., stainless steel, titanium, were considered but stability, handling and manufacturing considerations indicate that the thicker gages in aluminum are more practical. Physical properties used in this analysis are:

**Ftu = 62,000 psi
Fty = 50,000 psi
Fcy = 50,000 psi

E = 10.5 (10^6) psi
G = 4.0 (10^6) psi

*Ref to NAA Document MH01-05050-414
**NOTE: In order to hold a 1.15 margin on yeild, a Ftu value of 60,800 psi should be used. These values are for sheet and plate in the T-87 temper. Subsequent analysis will reflect extruded tube allowables as well.

4.1.1.3.2 Analysis -

a. Computer Analysis of Basic Structure for Inertia Loading

The basic structure was analyzed for strength and stiffness requirements using the idealized structure shown on Figure 4.1.1-2. A Martin developed computer program utilizing the IBM 1130 computer was used to analyze the structure.

TABLE 4.1.1-I

MINIMUM STRUCTURAL FACTORS OF SAFETY

	Yield	Proof	Ult or Burst
<u>General Structure</u>			
Test Qualified	1.15		1.4
Non-Test Qualified	1.15		3.0
<u>Fluid Systems</u>			
Pressure Vessels*		1.33	2.0
Reservoirs		1.33	2.0
Hose Tubing and Fittings			
(DIA 1.5")		2.00	4.0
(DIA 1.5")		1.5	2.5

*Pressure vessel proof factor shall be 1.33 when pressure is applied as a singular force.

(Refer to NASA-MSC RFD number BG681, dated 26 May, 1967, Title: "AAP Payload Integration Statement of Work")

Legend:
6 = Node Point
6 = Member No.
——— = Actual Member
— — — = Axial Member equivalent to rectangular plate

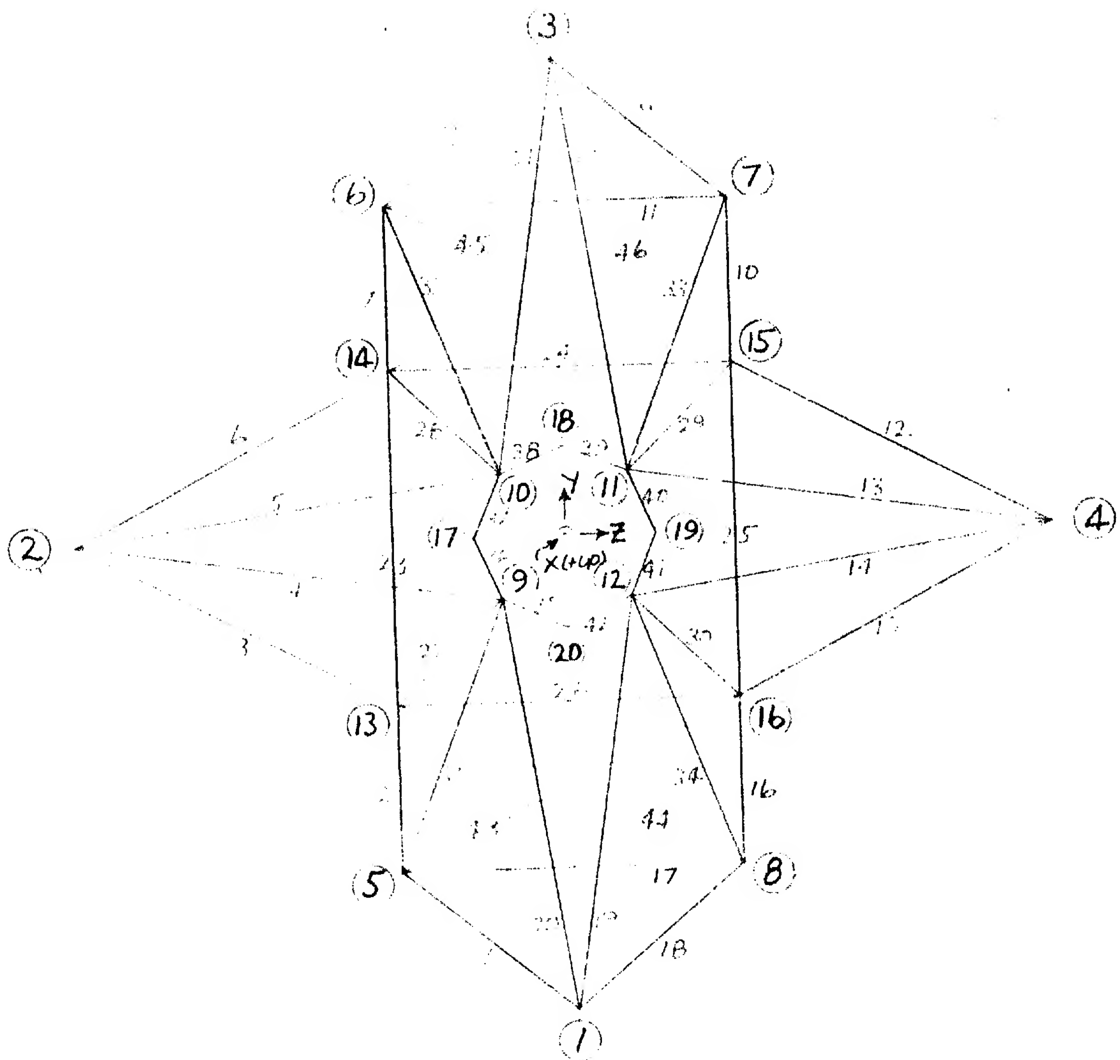


Figure 4.1.1-2 Computer Structural Model

All members are considered to be axially loaded with pinned ends except for the upper ring structure. The ring is subdivided into equivalent chord members which have axial stiffness, torsional stiffness and bending stiffness about both axes. The pressure shell and sheet metal skin of the external equipment support structure are not included as structural elements in the computer analysis of the basic structure, but are treated later in this report.

The member loads obtained from the computer runs are tabulated in Table 4.1.1-II along with member allowable loads and margins of safety.

b. Computer Analysis of Basic Structure for Transportation Docking -

The basic structure defined in Figure 4.1.1-2 was used in the transposition docking analysis. Preliminary transposition docking loads were calculated using North American Aviation Document MH01-05050-414. The three point loading shown in this document was considered to be transferred by the docking collar to the four upper longeron points of the structural model. The maximum member loads shown in Table 4.1.1-III were tabulated from the computer run.

c. Computer Analysis of Equipment Racks -

The two equipment support structures were analyzed independently of the basic structure. Since the two structures are identical in configuration it was possible to analyze one structure with two different sets of loads. The computer program previously discussed was used to determine member loads and reactions at the basic structure interface points.

Figure 4.1.1-3 shows the idealized structural model with node point coordinates given in Table 4.1-III. The structure is made up of pinned end members, some of which are the equivalent in stiffness to the skin plates. The equivalent member loads are used to analyze selected skin panels as shown in Table 4.1.1-IV. Maximum loads are shown in Table 4.1.1-V.

Table 4.1.1-II

BOOST CONDITION - CRITICAL MEMBER LOADS

Member	Length (in)	Area (in)	Ultimate Load (lb)	Allowable Ultimate Load (lb)	Ultimate M.S.
1, 8, 9, 18	51.6	.473	5,80DC	7,52DC	.30
2, 7, 10, 16	45.3	.59	8,94DC	11,80DC	* .32
3, 6, 12, 15	91.8	.934	15,20DC	16,40DC	.08
4, 5, 13, 14, 19, 20, 21, 22	139.9	1.675	9,15DC	11,55DC	.19
11, 17	59.4	.473	4,49DC	7,31DC	* .63
23, 24, 25, 26	59.4	.943	14,35DC	23,80DC	* .66
27, 28, 29, 30	105.6	.5	8,120T	31,0DOT	Large
31, 32, 33, 34	121.8	.3	2,010T	18,60DT	Large
35, 36, 37, 38, 39, 40, 41, 42	12.63.	A= .4 Imajor= 13. Iminor= .5	See section 3.2.5.10		

*Margins shown are for axial loads only. See Table 4.1.1-V for beam-column margins.

Table 4.1.1-III

DOCKING CONDITION MAXIMUM MEMBER LOADS

Member	Length (in)	Area (in)	Ultimate Load (lb)	Allowable Ultimate Load (lb)	Ultimate M.S.
1, 8, 9, 18	51.6	.473	1,267C	7,52DC	Large
2, 7, 10, 16	45.3	.59	1,526C	11,80DC	Large
3, 6, 12, 15	91.8	.934	2,021C	16,40DC	Large
4, 5, 13, 14, 19, 20, 21, 22	139.9	1.675	1,643C	11,55DC	Large
11, 17	59.4	.473	823C	7,31DC	Large
23, 24, 25, 26	59.4	.934	1,442C	23,80DC	Large
27, 28, 29, 30	105.6	.5	345	1,500	Large
31, 32, 33, 34	121.8	.3	506	1,130	Large
35, 36 37, 38, 39, 40, 41, 42	12.63	A= .4 Imajor= 13. Iminor= .5			Large

TABLE 4.1.1-IV

Summary of Detail Parts Stress Analysis

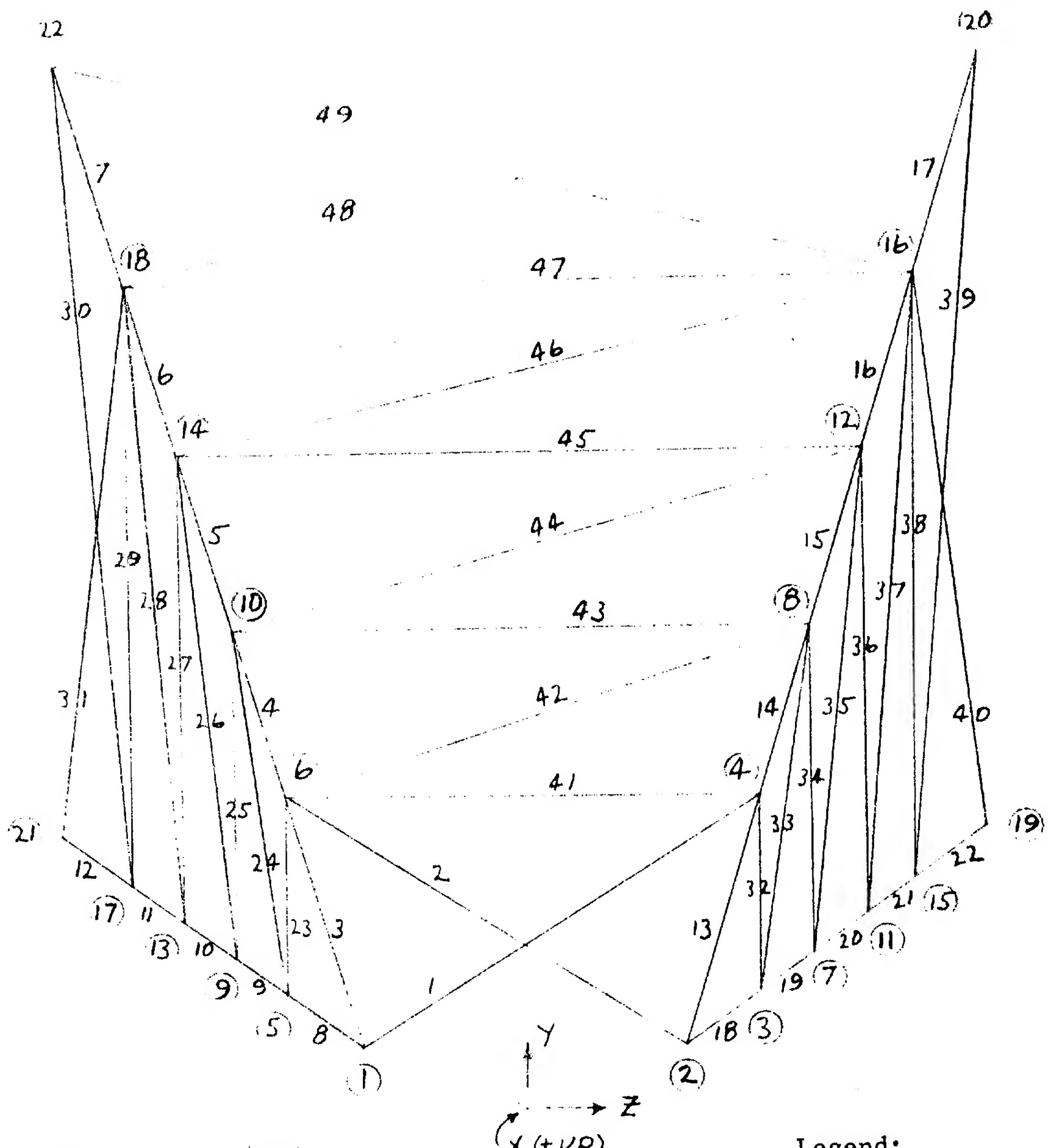
PART	CRITICAL LOAD CONDITIONS	CRITICAL AREA	MARGIN OF SAFETY
Fittings at Node Points 1-4	2	Lower Flange Lug	.18
Fittings at Node Points 14-16	2	Equipment Truss to Fitting Attach Bolts	.02
Fittings at Node Points 9-12	2	Upper Flange	0
Members #23-26	2-3	Beam-Column	.12
Lower External Equipment Panel Stiffener	1	Compression Flange	.18
Member #77	1	Beam-Column	.006
Member #2	3	Beam-Column	0
Member #29	2	Beam-Column	.31
Skin Panel 15-16-19-20	2	Stability	.50
Skin Panel 22-20-18-16	3	Stability	.03
Cone Docking Collar Ring Frame	2	Bending at Node Point 20	1
Truncated Cone	4	Skin to Longeron (members 27-30) weld	.16
Spherical Cap	4	Skin Tension	1
Spherical Cap-Cone Frame	4	Stability	1

Table 4.1.1-V

Equipment Rack Maximum Member Loads

Member	Length	Ultimate Axial Load
1, 2	60.05	100#T, 906#C
3, 13	51.91	606T
4, 14	13.01	47DC
5, 15	13.65	714C
6, 16	13.36	127DC
7, 17	30.02	194DC
8, 18	45.13	1415T
9, 19	11.29	1310T
10, 20	12.18	1070T
11, 21	11.50	396T
12, 22	25.BD	704C
23, 32	19.0D	153C
24, 33	27.88	171T
25, 34	24.80	426C
26, 35	33.89	165C
27, 36	28.50	145DC
28, 37	37.28	562C
29, 38	33.80	580C
30, 39	55.90	720T
31, 40	38.78	2080C
41	39.0D	395C
42	41.77	745C
43	40.40	264C
44	45.66	79C
45	47.00	718C
46	50.97	1360C
47	50.40	508C
48, 49	62.41	1675T, 218DC

CF Compression
T= Tension



Reactions at Node Points 1, 2, 19, 20, 21 and 22

Legend:
9 = Node Point
9 = Member No.

Figure 4.1.1-3 Computer Structural Model - Equipment Racks

d. Lateral Stiffness Analysis

The stiffness analysis was performed using the structural model defined in Figure 4.1.1-2. Unit loads acting in opposite directions were applied at diametrically opposite node points. Deflections at the loaded node points were obtained from the computer program. Stiffness values of 50,300 lb/in and 93,000 lb/in were calculated across the Y and Z diameters respectively.

e. Computer Analysis of Beam-Columns -

Certain members of the carrier structure carry lateral loads as well as the axial loads shown in Table 4.1.1-II. These members were analyzed as beam-columns using a Martin developed Beam Column Computer Program.

This program for the IBM 1130 computer uses an iteration procedure to calculate moments due to axial and lateral loads in a beam column. The member can be subdivided into as many as 40 segments which allows the use of varying area and moment of inertia. Lateral load types include uniform load, triangular load distribution, concentrated load at any point, applied moment at any point, and initial column eccentricity. Any combination of the above types can be used.

f. Detail Parts Analysis -

Table 4.1.1-IV contains summaries of the analysis performed on key details of the carrier structure.

4.1.2. Thermal Control Subsystem

4.1.2.1 General - Mission success depends upon thermal control for all phases of launch through orbit operation. The carrier TCS baseline has been developed based on requirements, configuration constraints, hardware availability and design trade studies. The importance of a reliable and flexible thermal control subsystem design is recognized. Throughout studies, emphasis was placed on approach simplicity, flexibility to meet changing requirements, growth potential, and minimum schedule risk.

Analysis shows that an active thermal control system (fluid loop, pump and thermal radiator) provides the TCS reliability and flexibility requirements. The thermal design approach, description, and performance is outlined in the sections to follow.

4.1.2.2 Requirements - The carrier will be attached to the CSM throughout its orbit life. Orbit altitudes have been specified as 120 to 140 n. miles at inclinations of 40 to 50 degrees. The thermal design is based on a ground rule to not impose constraints on the mission. This includes no restriction on launch date, launch time or carrier altitude between 100 and 140 n. miles. The 100 n. mile minimum orbit altitude allows for some orbit decay. The orbital external heat fluxes are not significantly different between 100 and 140 n. miles. At the lower altitude, influences of the earth are greater but the percent time in the earth shadow is slightly larger which yields slightly lower average orbit solar heat fluxes. Table 4.1.2-I shows orbital criteria for 100 and 140 n. miles. The sun angle to orbit planes shown in this table are based on the extremes caused by orbit inclination of 40 and 50 degrees and sun angles at the solstices of $\pm$ 23.5 degrees.

4.1.2.3 Temperature Requirements and Heat Loads - There is a large number and variety of experiments, and subsystem equipment that requires thermal support. They are located in the two external equipment bays, on the outside carrier truss, and within the pressurized compartment.

TABLE 4.1.2-I, ORBITAL CRITERIA

Parameter	100 n. miles	140 n. miles
A) Orbit time (minutes)	87.97	89.46
B) 0 degress, sun angle to orbit plane		
1. Shadow time (min)	37.31	36.74
2. Shadow angle (deg)	152.69	147.84
C) 16.5 degrees, sun angle to orbit plane		
1. Shadow time (min)	37.02	36.38
2. Shadow angle (deg)	151.49	146.42
D) 50 degrees, sun angle to orbit plane		
1. Shadow time (min)	33.45	32.04
2. Shadow angle (deg)	136.90	128.94
E) 73.5 degrees, sun angle to orbit plane		
1. Shadow time (min)	16.51	6.34
2. Shadow angle (deg)	67.54	25.50

4.1.2.3

Table 4.1.2-II, Thermal Control System Requirements, lists experiments and subsystem equipment temperature requirements and heat loads by major carrier location. Further study and coordination with the experimenters is required to more firmly establish the actual thermal interfaces with the carrier. Some of the temperatures shown in Table 4.1.2-II are known to be experiment requirements which are fulfilled by the experimenter and not by the carrier. A good example of this is experiment D017, Solid Electrolyte CO_2 Reduction where the 1688 to 1832° F required is supplied by the experiment through the use of internal electric heaters.

4.1.2.4 Typical Thermal Duty Cycle - In order to design the thermal control system, it is necessary to determine the internal heat loads. An evaluation was made of all items of equipment and experiments located in the two external bays that generate heat. All heat generated within these two bays is assumed controlled by the active thermal control system.

Figure 4.1.2-1 shows equipment operation time lines, both experiment and subsystem, which contribute to a typical peak heat load in the two external bays. When similar time lines are generated which detail equipment operations for the full standard applications day it is possible to establish heat production rates on a time base. Figure 4.1.2-2 shows such a heat production history for a standard applications day. From Figure 4.1.2-2, it is seen that the maximum heating rate is 3680 BTU/hr for a period of 8 minutes. Average heat production during that portion of the day when major activities occur is 1300 BTU/hr. When only housekeeping activities are in process the average rate is 256 BTU/hr. During peak heat loads the active system will not carry off excess heat at the rate it is being produced and the subsystems will rise in temperature slightly. An analysis was made of items contributing to the peak heat load assuming that during the peak heat load, no heat was being rejected by the radiator. The maximum system temperature rise was about 5°F. The heat absorbed during the transients will be rejected during "off" periods and forms a part of the maximum time average heat load of 1300 BTU/hr.

Subsystem/Module	Remarks
I. EXPERIMENT SUBSYSTEM:	
A. EARTH RESOURCES & APPS A	
<u>EXTERNAL BAYS</u>	
1. E06-7 Wide Range Imager - Scanner - Cassette, supply - Cassette, take up	1 Spcl Cold Plate, 30W/1½ in^2: 158°F Max., Stored He gas for cooler
2. E06-9a Infra-red Radiome -Radiom/Elect.	LN_2 required
3. E06-9b Infra-red Spectro -Spectrom/Elect.	LN_2 required
4. S039 Day/Night Camera -Camera -Electronics -Recorder	
5. S040 Dielectric Tape Can -Camera -Electronics	
6. S043 Temperature Soundir -Radiometer -Electronics	Cold Plate req'd at head: 80 watts/42 in^2
7. S044A Electrically Scanr Micro Wave Radiome -Antenna -Electronics	LN_2 or LHe required
8. S048 UHF Sferics Detectc -Antenna -Amplifier -Data System	

Subsystem/Module	Remarks
I. EXPERIMENT SUBSYSTEM: (continue	
INTERNAL TO CARRIER	
1. Metric Camera	
-Camera & Magazines	Opt glass windows Press 2-15 psia
2. S042 Multi-Spectral Can	
-Camera (6)	
-Magazine (6)	Opt glass windows. Press 2-15 psia. Press 2-15 psia
EXTERIOR TO BAYS AND CARRII	
1. Multi Frequency Micro \ Radiometer	
-Antenna/Electronic:	
B. BIOSCIENCES/TECHN., ASTRON(AND OTHER EXPERIMENTS	
1. D008 Radiation Measure	
-Active Dosimeter	
-Passive Dosimeter	
2. D009 Simple Navigation	
-Sextant	
-Stadimeter	
-Accessories	
3. D017 Solid Electrolyte Reduction	
-Electolyte	
-Electronics	
4. S015 Influence of Zerc Human Cells	
-Camera/Microscope & Biopacks	Temperature controlled to 94-99°F by internal means

Table 4.1.2-II, THERMAL CONTROL SYSTEM REQUIREMENTS

Subsystem/Module	Power Requirements(watts) Standby/ Warm Up	Average Operate	Peak	Assumed Conversion To Heat In	Survival Min °F	Survival Max °F	Operate Min °F	Operate Max °F	Assumed at Location	Pressurization Stowed	Pressurization Operate	Remarks
I. EXPERIMENT SUBSYSTEM: (continued)												
5. S016 Trapped Particle Asymmetry	-	-	-	Neglect		140		140				
-Main Nuclear Package										Press	Not Press	
-Background Nuclear Stack										Press	Press	
6. S017 X-Ray Astronomy					0	150	0	150				
-X-Ray Sensor Package		2								Not Press	Not Press	
-C&D Panel		28								Press	Press	
-Electronics		104								Not Press	Not Press	
-Data Package		77								Not Press	Not Press	
7. S018 Micrometeoroite Collection -Collection Device		-		Neglect	40	85	40	85		Press	Not Press	
8. S019 Ultra Violet Astronomy -Spectrograph/Film Unit -Finder Telescope -Focusing Microscope	Self Contained Batteries			Neglect		100	50	80		Press	Not Press	
9. S020 X-Ray/Ultra Violet Solar Photography -Spectrometer/Film	7	7	70			100	32	100		Press	Not Press	100° Max temp is film constraint
10. T002 Manual Navigation Sightings	Self Contained Batteries			Neglect								
-Sextant										Press	Press	
-Accessories										Press	Press	
11. T003 Aerosol Particle Analyzer -Nephelometer	Self Contained Batteries			Neglect	0	120	40	80		Press	Press	
12. T004 Frog Otolith Function -Support System	5	20					60	70		Not Press	Not Press	Self contained thermal control system. Self contained pressure system.

Table 4.1.2-II, THERMAL CONTROL SYSTEM REQUIREMENTS

Subsystem/Module	Power Requirements(watts) Standby/ Warm Up	Average Operate	Peak	Assumed Conversion To Heat In Module	Survival Min °F	Survival Max °F	Operate Min °F	Operate Max °F	Assumed at Location	Pressurization Stowed	Pressurization Operate	Remarks
II. EQUIPMENT SUBSYSTEMS												
1. Data Management System												
-Signal Conditioner				Neglect			35	100	Case			30 watt input high efficiency
-PCM 5.12 KBPS Encoder		10		100%								
-Tape Recorder		10		100%								
-VHF TMTR A		84		100%				160	Case			
-VHF TMTR B		84		100%				160	Case			
-VHF TMTR C		84		100%				160	Case			
-VHF Multiplexer		-		Neglect	-60	200	0	200	Case			
-Time Generator		16										
-Experiment Data Handling syst (GFE)		104		100%			TBS	TBS	Case	TBS	TBS	
-Experiment Record Select Switch		-		Neglect					Case			
-S-Band TMTR		8		100%				118	Base			
-S-Band Power Amplifier		80		100%			(nom)	118	Base			
2. Electrical Power & Distribution System												
-Batteries	73	160	950	5%			55	90	Base	Sealed Units		
-Inverters	TBS	TBS	TBS	70%					Base	Sealed Units		
-Switches, Motor			11	Neglect	-35	+160	25	100	Case	Sealed Units		
-Circuit Breakers		-	-	Neglect			-40	250	Case			
-Diodes		20		Neglect			-13	212		Sealed Units		
3. Display and Control Syst												
-Control Box	TBS	TBS	TBS						Case			Identified as solid state design
4. Thermal Control System												
-Motor, Pump		25/43		100%					Case	Sealed Unit		

TBS = To Be Supplied

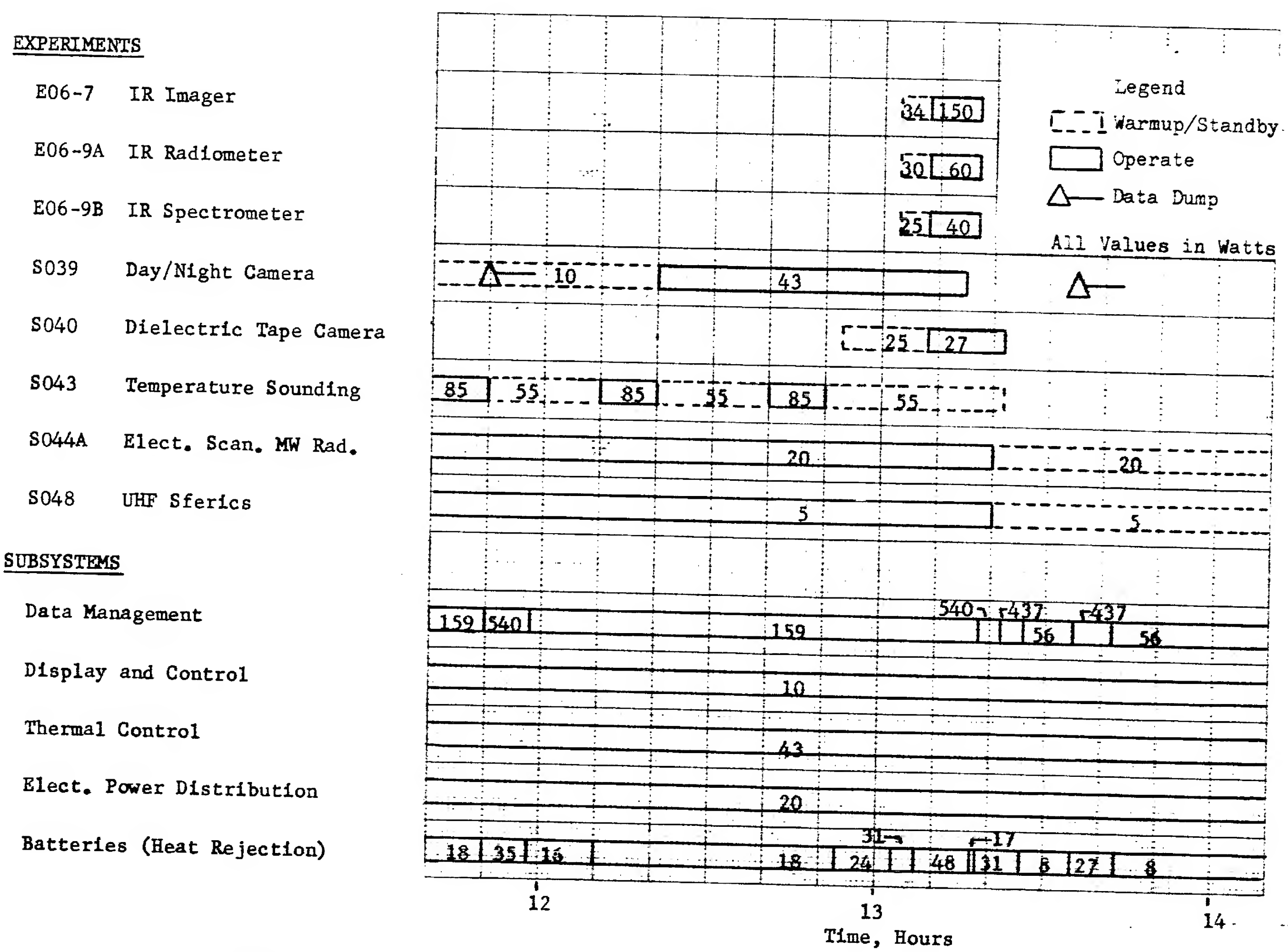


FIGURE 4.1.2-1; EXTERNAL BAY THERMAL LOAD TIME LINES, TYPICAL PEAK LOAD ON STANDARD APPLICATIONS DAY

MARTIN MARIETTA CORPORATION
DENVER DIVISION

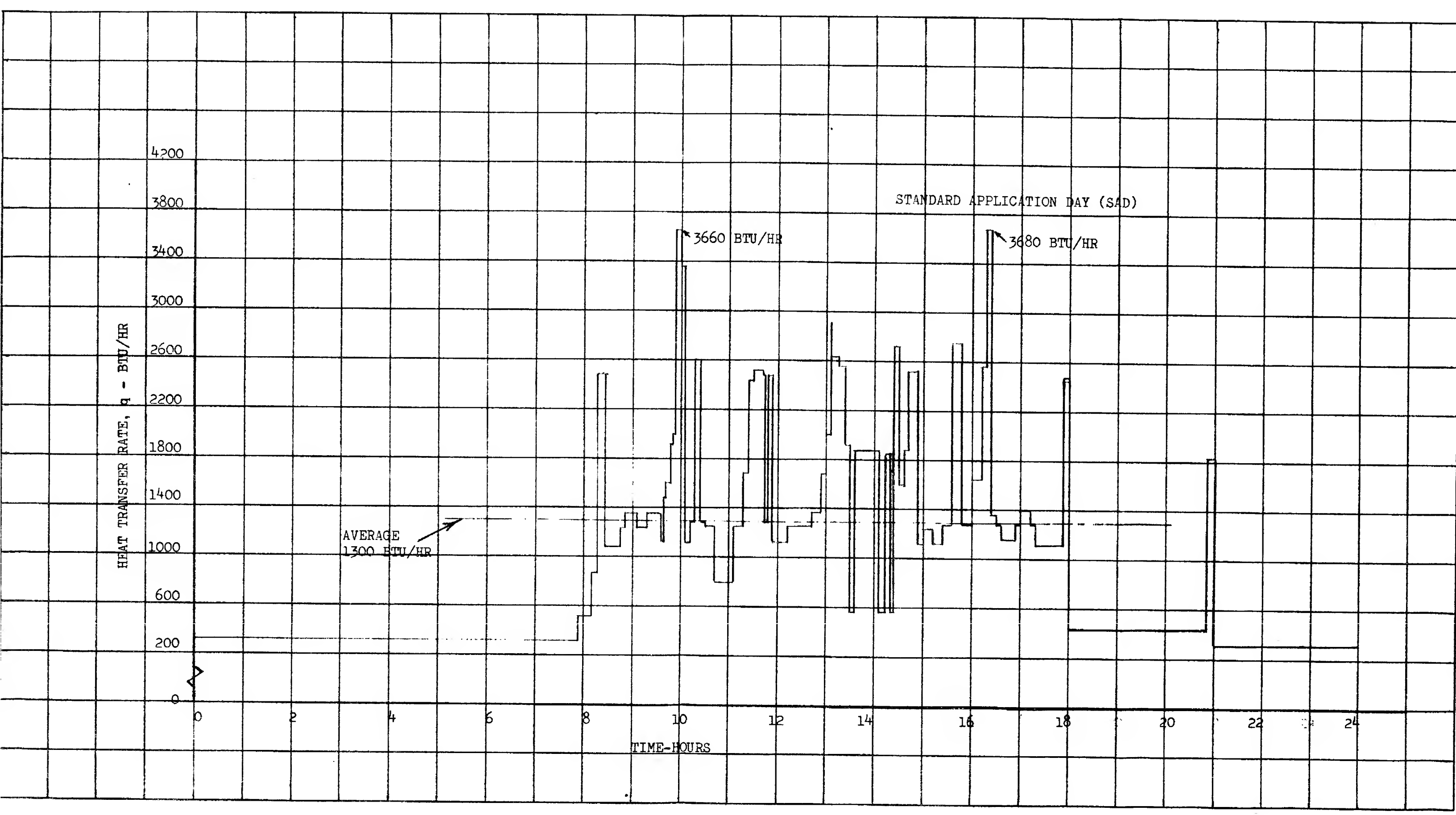


FIGURE 4.1.2-2, TYPICAL HEAT LOAD CYCLE

4.1.2.5 Subsystem Description - The TCS uses an active coolant loop to provide temperature control over wide ranges of internal heat loads and orbit heat fluxes. Passive control in the form of insulation, coatings, and thermal isolators are used in conjunction with the active subsystem to provide overall thermal balance to the carrier. It is planned to insulate the entire main carrier body with super insulation similar to that which was developed for Martin Prime Vehicle Program. This insulation will be in the form of blankets attached to the outside of the carrier. The purpose of the insulation will be to neutralize the influences of orbital heat flux variation. The precise details of insulation, outer covering, attachment methods have yet to be determined. Analysis will show the influences of the SLA attach truss and the degree of isolation and insulation required. Radiator panels will be installed outside of the insulation for heat dissipation control. Insulating the outside of the basic carrier structure allows cold plates and components to be attached directly to the structure. This increases the thermal inertia of the carrier and thus provides for more consistent temperatures throughout the carrier.

4.1.2.6 Active Subsystem Description (See Figure 4.1.2-3) - The active subsystem consists of two completely separate coolant transport loops to provide system redundancy. Refer to PR 29-42, Thermal Control System Selection Study. Heat rejection is accomplished by use of a tube/fin space radiator made up of four flat panels located on external areas of the spacecraft.

Radiator control is accomplished by the use of a radiator bypass line. The bypass line flow and the radiator outlet flow are directed to the thermal control valves. These valves contain slotted spools that are spring loaded against a wax vernatherm elements. The elements are immersed in the valve outlet flow. They continuously modulate spool position in order to accomplish the mixing required to regulate coolant temperature.

The outlet from the thermal control valve is directed through a ground cooling Freon boiler heat exchanger. The boiler vaporizes Freon which is supplied from a ground service unit for primary loop cooling, during ground checkout and on pad operations. Accumulators

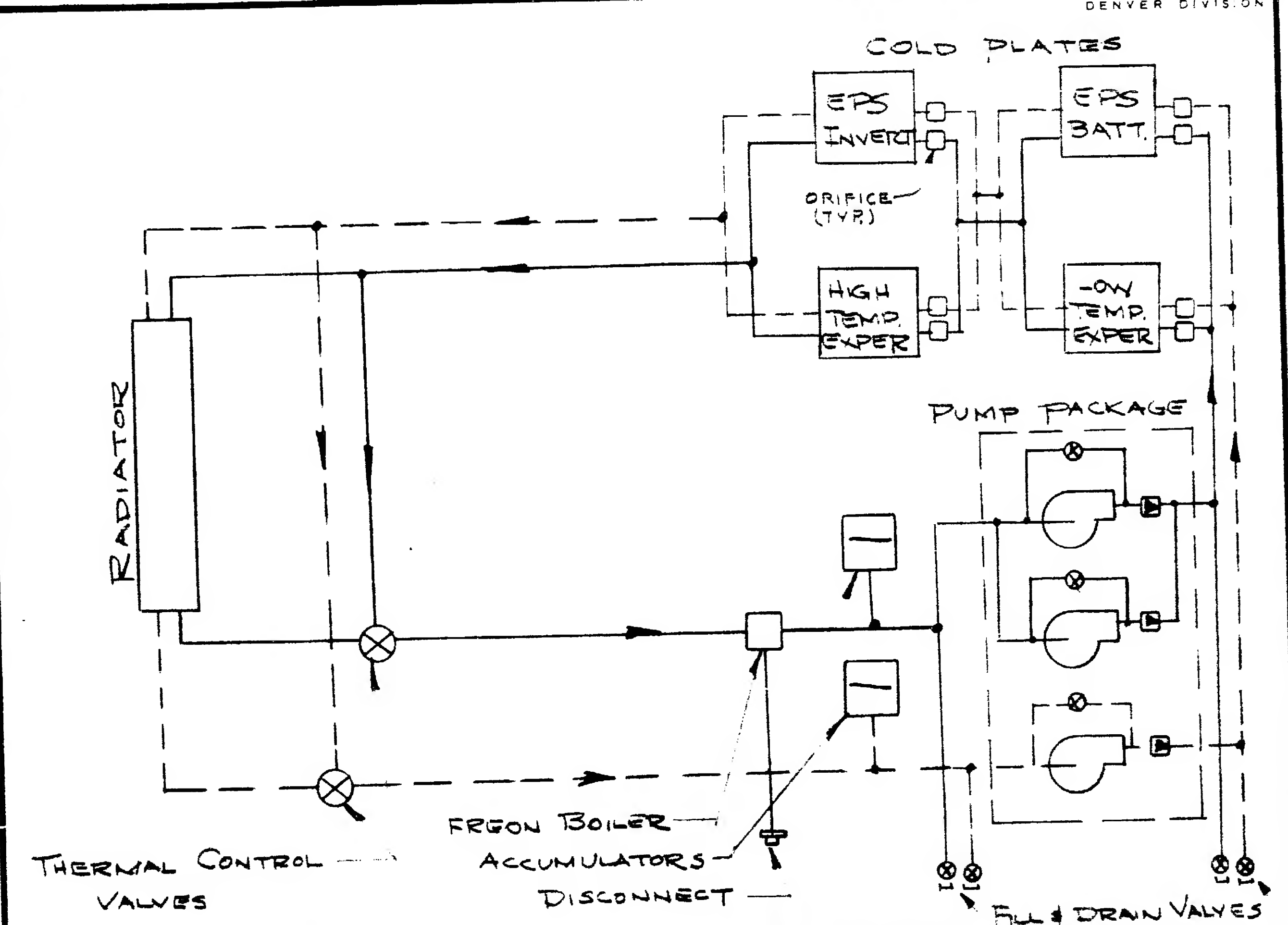


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FIGURE 4.1.2-3, THERMAL CONTROL SYSTEM SCHEMATIC

4.1.2.6

are installed in the pump inlet lines of each system. These units provide system expansion volume to accommodate coolant temperature changes.

A pump package consisting of three pumping units is used for coolant circulation (refer to PR 29-48, TCS Pump Selection Study). The primary system is operated from one pump. The secondary system has two pumps available that are connected in parallel within the pump package. Check valves are included to prevent back flow through a pump that has been shut down. Relief valves are provided on each pump to protect the system from overpressure. Pump inlet filters are provided to protect the pump and other system components from contamination.

Experiments and subsystem components requiring cooling are provided with cold plates. In order to maintain efficient heat transfer from these units to the cold plates a filler material is used to maintain good contact on the entire cold plate surface. The cold plates consists of aluminum plates with serpentine tubes brazed to the outside surface (refer to PR 29-24, Preliminary Cold Plate Thermal Study). Coolant at the required flow rate and temperature is circulated through the tubes to remove heat. The cold plate circuit uses groups of experiments requiring similar temperature profiles and proportions heat flow by means of coolant flow control orifices.

The system is filled to a pressure of 35 psia. Maximum pressure rise across the pump is approximately 25 psia producing a maximum system operating pressure of 60 psia.

Mechanical threaded joints are required at each component in order to accommodate the use of readily available hardware and provide for replacement. Plumbing joints in other portions of the systemwill be welded or brazed. All plumbing lines are thin wall stainless steel which may be readily assembled.

4.1.2.6.1 Active Subsystem Operating Modes -

Ground Mode - During checkout and on the pad operations the primary system only will be operating. Since the radiator is ineffective during ground operation heat

4.1.2.6.1

rejection is accomplished with the Freon boiler. System temperature and pressure signals at the ground console are used for temperature control.

Flight Mode - Initial system operation will be with only the primary loop operating. In the event of system malfunction, the primary pump will be shut down. The secondary pump will then be automatically activated. In the event of subsequent malfunction of the primary flow loop, the redundant flow loop shall be manually activated by energizing the redundant flow loop pump.

4.1.2.7 Radiator Performance - The thermal radiator is the key to the active thermal control subsystem. The radiator with its control system, controls the heat dissipation to space. The control system is based on a simple bypass line and control valve which provide for bypass flow around the radiator to conserve heat within the carrier under low heat load conditions. The control system was chosen over a selective stagnation radiator or regenerative heat exchanger control methods due to its simplicity and high turndown ratio (refer to PR 29-6, Preliminary Thermal Radiator Analysis). Freon 21 was chosen as the coolant for the active TCS due to its low freezing point and good heat transport properties (refer to PR 29-5, Coolant Selection Trade Study).

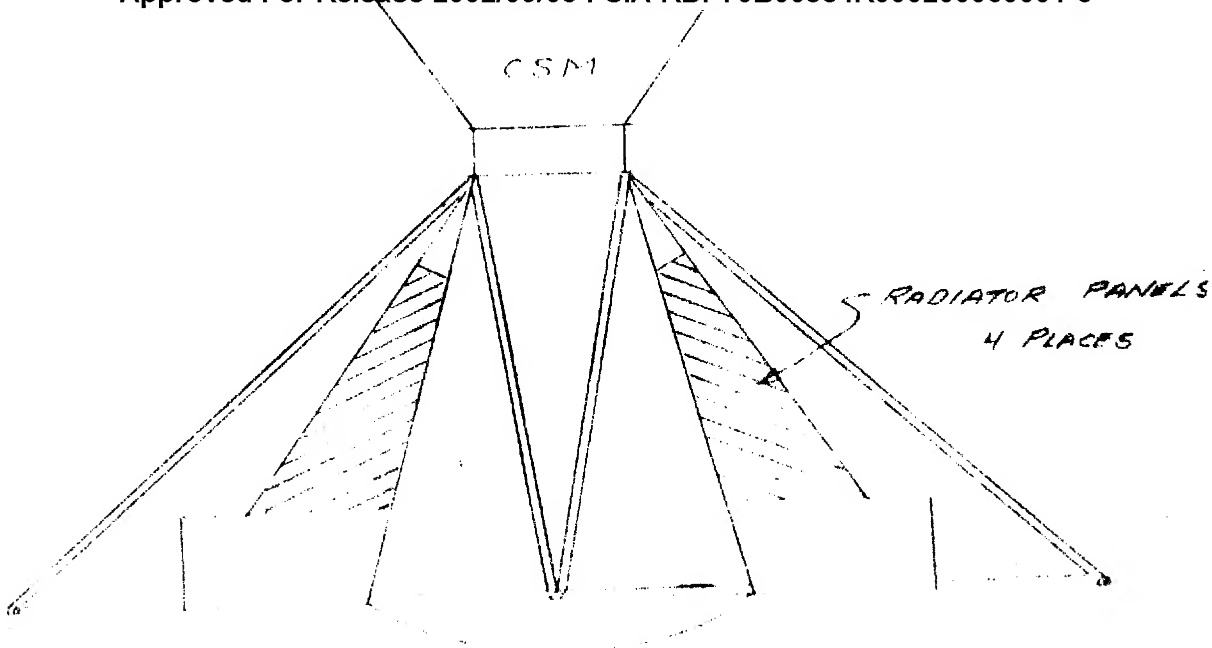
A series tube radiator panel configuration was chosen over parallel flow tubes to eliminate flow distribution problems. To match the carrier configuration and to provide flexibility to the radiator system, radiator panels have been located on two opposite sides of the carrier. The location of the panels was chosen to minimize space view blockage by the SLA support structure. Two opposite sides of the carrier were chosen for the radiator locations to minimize the effects of vehicle attitude which could expose one side to the sun, or directly to the earth, thus degrading the performance of only half the radiator area at a time. In addition to this, since area was available for four identical panels, a flow crossing arrangement was chosen. Under this arrangement, at minimum internal heat loads and minimum external heat flux, the coolant will not remain long enough in any one panel to freeze before it passes

4.1.2.7

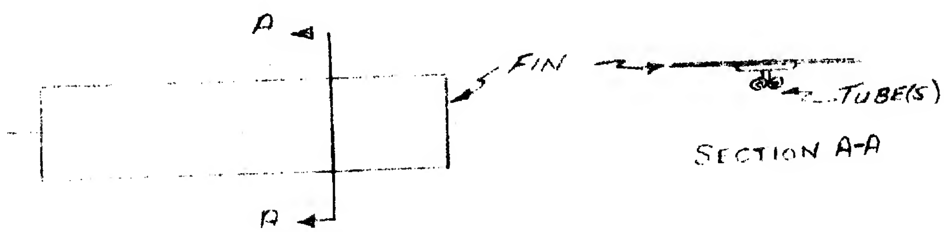
out of the system or proceeds to a warmer panel. The radiator configuration, carrier location and flow circuit is depicted in Figure 4.1.2-4.

The radiator is sized based on maximum average internal heat loads and maximum expected external environmental heat flux. From the heat load duty cycle evaluation, the maximum average heat load is 1300 BTU/hr. From an evaluation of average orbital external heat fluxes, the maximum average absorbed heat flux was determined to be 53 BTU/hr ft^2. This condition occurs when the carrier orbit plane is inclined to the sun at an angle of 73.5 degrees at 140 n. miles and the carrier is positioned such that the one set of radiator panels faces towards the sun and the other faces the earth. With this orbital condition one set of panels absorbs 91.5 BTU/hr ft^2 and the other 14.5 BTU/hr ft^2. These absorbed heat flux values do not include the influences of the CSM or experiment carrier external structure. The inclusion of these influences, including shadowing, reflected sun and space blockage was beyond the scope of this study and will be included in later analyses. Based on maximum heating conditions, a total radiator area of approximately 24 ft^2 is required. Each radiator panel is therefore approximately 6 ft^2. With an average fin width (total) of 9 inches, each tubing run per panel will be about 8 feet long.

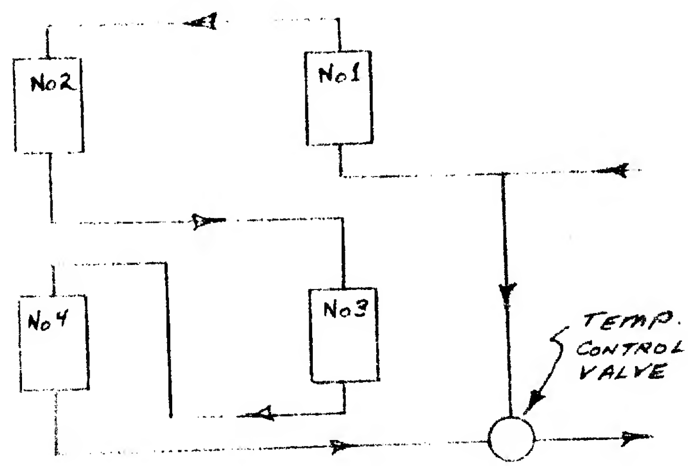
Using the size requirements for maximum heat load conditions, the performance of the radiator under minimum heat load conditions was studied. Minimum heat loads were based on only subsystems operating without any experiment heat loads. Also from a study of orbit conditions, a minimum external heat load orientation was chosen. Two conditions are obtained that give minimum external heat loads. One case is a carrier altitude that gives a low average heat load but all panels have some external heating. The second case is an altitude that gives one set of panels a zero external heating with an average of the four panels higher than for the first case. The second case is a condition where coolant freezing is most likely to occur. The two



RADIATOR PANEL LOCATIONS



RADIATOR PANEL CONFIGURATION



RADIATOR FLOW CIRCUIT

Figure 4.1.2-4 Radiator Configuration

4.1.2.7

minimum orbit conditions which gives the lowest absorbed external heat fluxes occur at 140 n. miles.

Case I - Sun angle = 73.5°

Zero sun

Panel No. 1 = 22.5 BTU/hr ft^2
No. 2 = 22.5 BTU/hr ft^2
No. 3 = 22.5 BTU/hr ft^2
No. 4 = 22.5 BTU/hr ft^2

Case II - Sun angle = 73.5

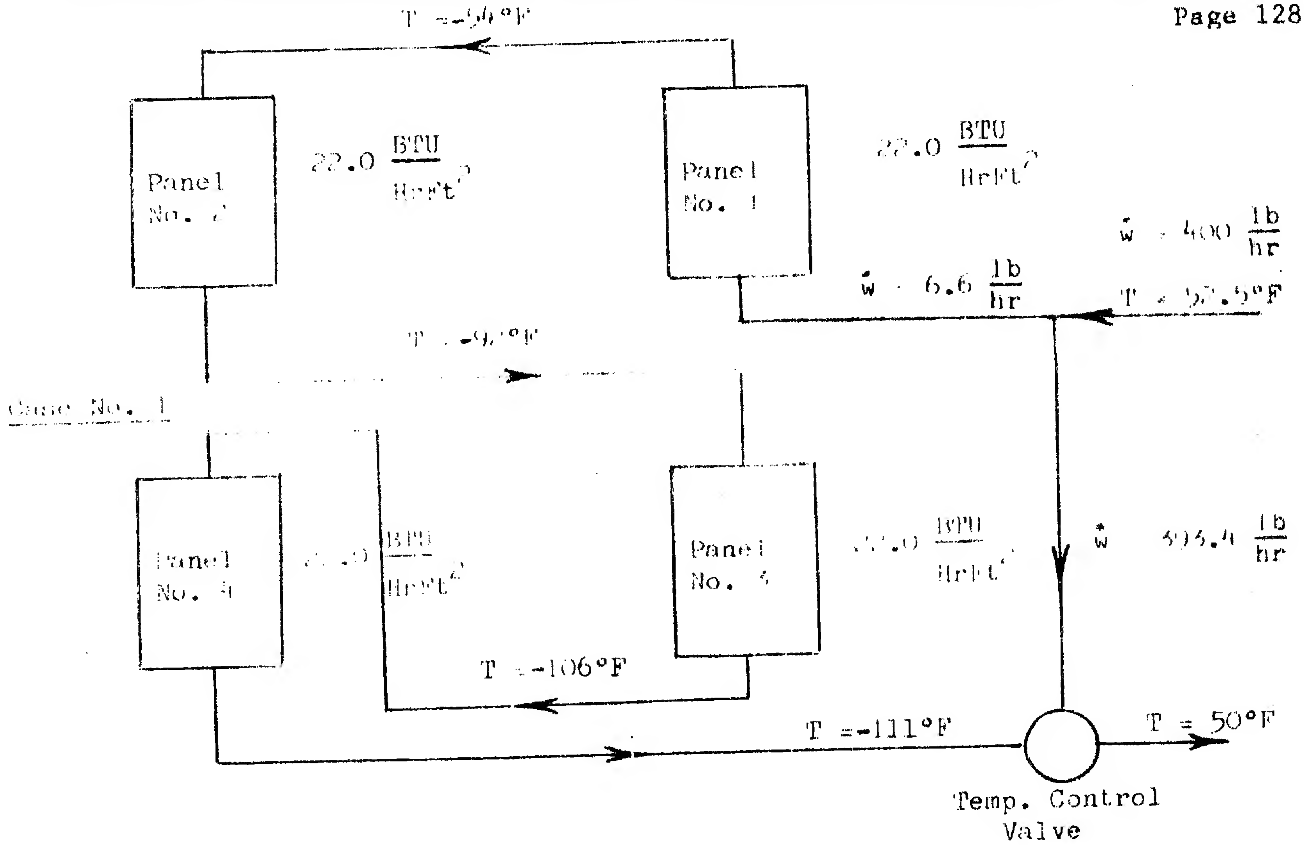
Zero sun

Panel No. 1 = 58 BTU/hr ft^2
No. 2 = 0
No. 3 = 58 BTU/hr ft^2
No. 4 = 0

Figure 4.1.2-5 shows the flow rates and temperatures for the two minimum heat load cases. It is seen that the second case, although having a higher minimum average absorbed heat flux has colder temperatures due to the one set of panels viewing deep space. A wide safety margin above coolant freezing point is available in spite of the conservatively low heat input criteria of Case II.

The analysis thus far has been based on steady state average heat load conditions. Continued studies are planned to determine worst case external heat fluxes including shadowing and influences of surrounding bodies and to evaluate orbit transient influences.

4.1.2.8 Coolant Loop Performance - The entire coolant flow loop was evaluated in conjunction with the radiator. Figure 4.1.2-6 shows temperatures and flow rates to match maximum average heat loads. Figure 4.1.2-7 shows the performance of the same system under minimum heat load conditions. It is readily seen that the thermal control system easily handles the heat load variations, without approaching the freezing point of the Freon 21 coolant.



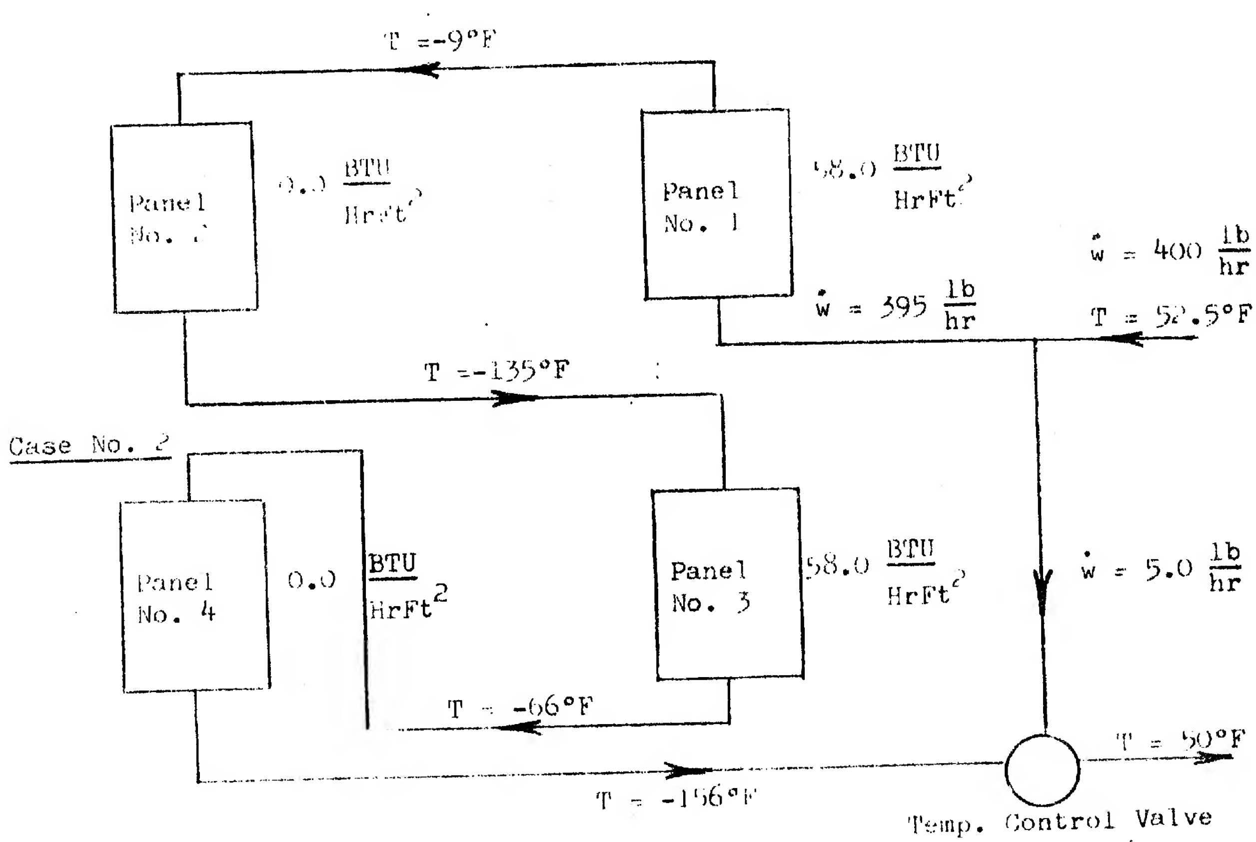


Figure 4.1.2-5 Radiator Performance Under Minimum Heat Load Conditions (Q_{out} = 256 BTU/hr.)

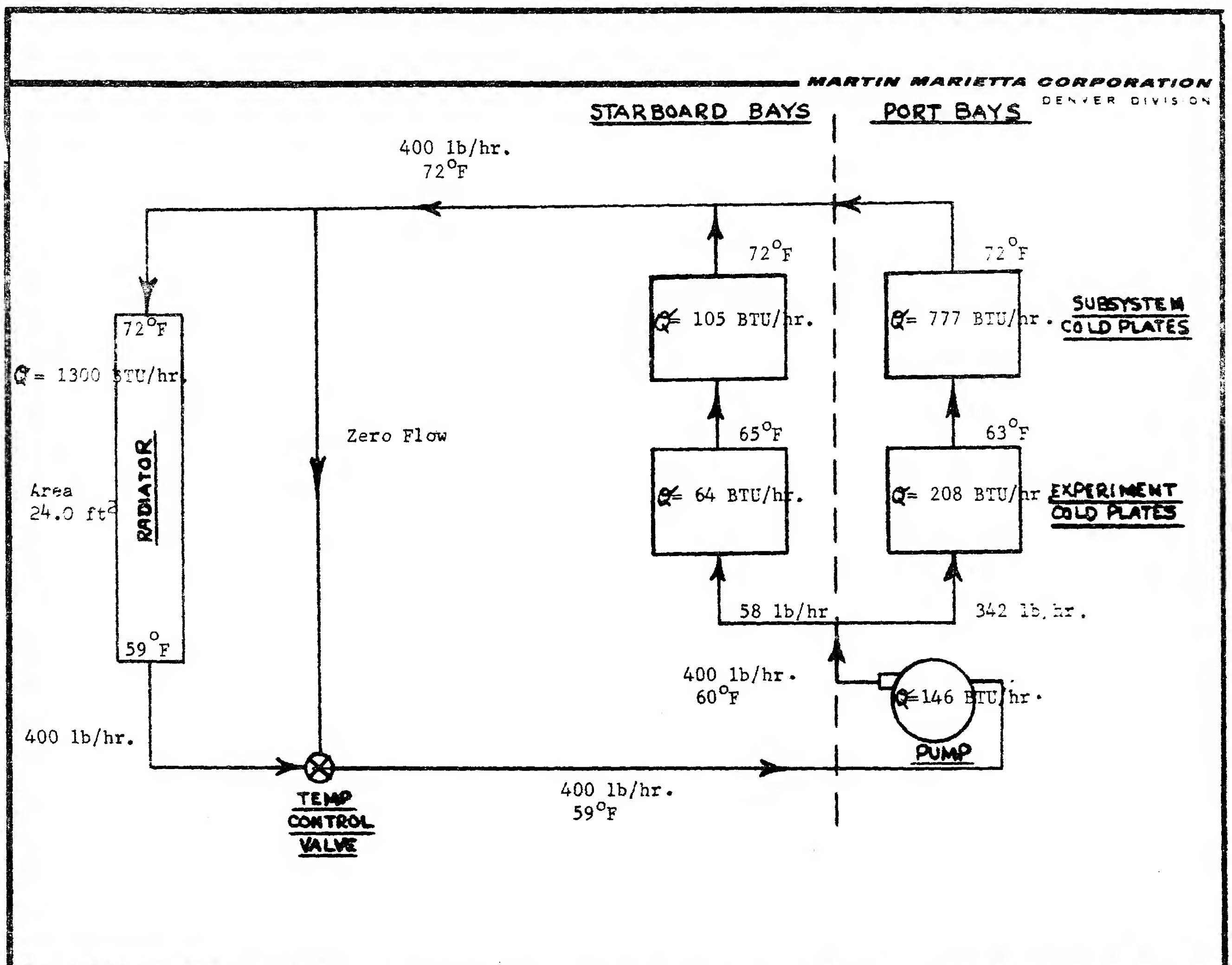


FIGURE 4.1.2-6, MAXIMUM HEAT LOAD CONDITIONS (MAXIMUM EXTERNAL FLUXES AND MAXIMUM AVERAGE INTERNAL LOADS)

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MARTIN MARIETTA CORPORATION
DENVER DIVISION

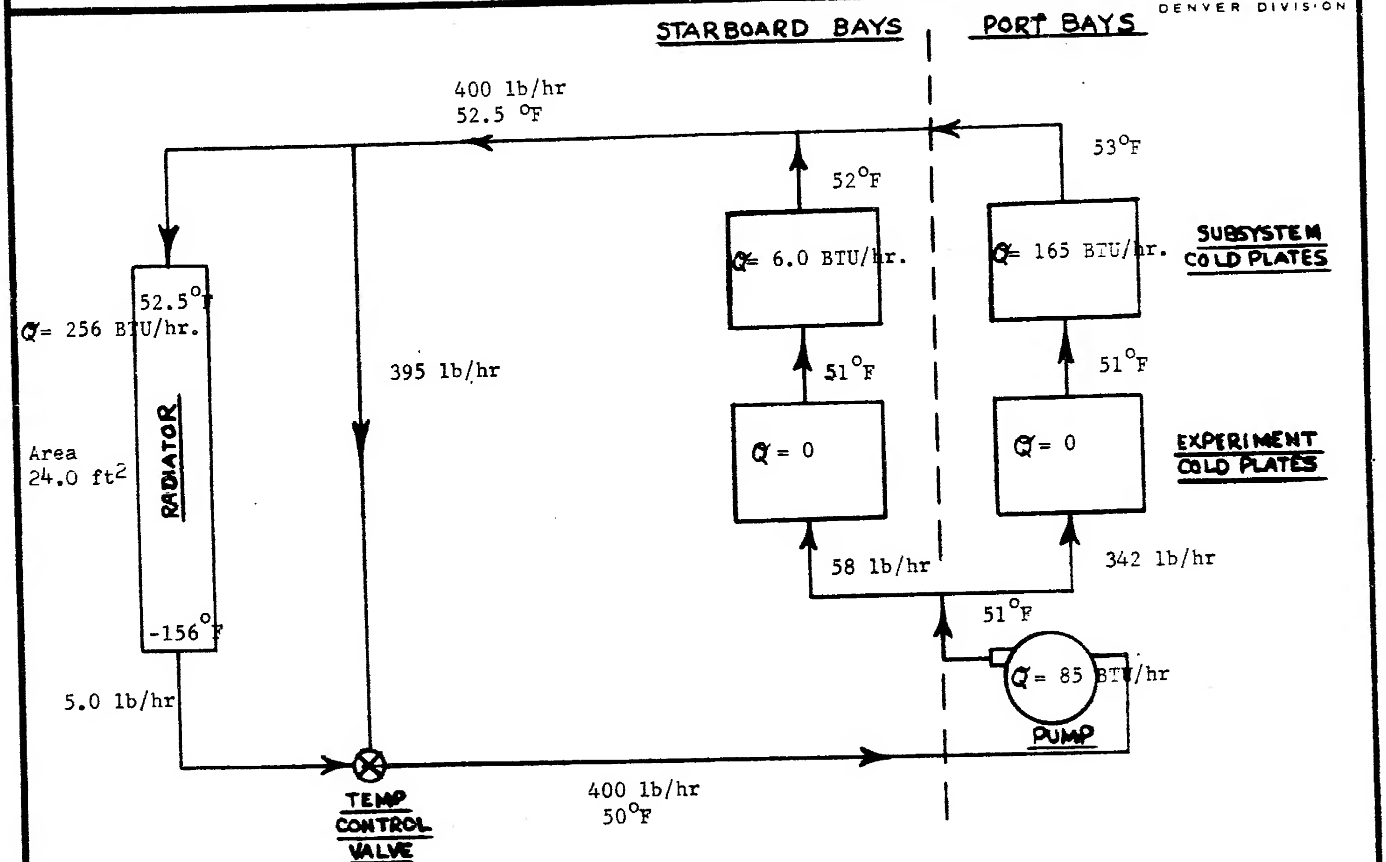

FIGURE 4.1.2-7, MINIMUM HEAT LOAD CONDITIONS
(MINIMUM EXTERNAL FLUXES AND MINIMUM INTERNAL LOADS)

4.1.2.8

A preliminary evaluation was made of the pressure drop through the entire system. It is currently planned to route one coolant line to each equipment bay. Within each bay, cold plates would be in series and parallel flow distribution as required. Tubing size has been tentatively selected as 3/8 inch OD thin wall stainless steel. Cold plates tubing has been selected as 3/8 inch OD aluminum tubing. Radiator is made from an aluminum extrusion with a flow passage of .311 inch ID. Based on these sizes an evaluation was made of the system. The following is a summary of the total system pressure drop.

Radiator	2.0 lb/in^2
Tubing	4.9 lb/in^2
Cold Plates	9.6 lb/in^2
Total	16.5 lb/in^2

4.1.2.9 Subsystem Hardware Status - Table 4.1.2-III depicts the potential hardware required for the active thermal control system. The radiator is a simple plate/fin unit similar in design to the unit developed for the Titan III transtage. It will be qualification tested at the Martin Marietta Space Chamber Facility. The pump package will be supplied by Hamilton Standard and is essentially the same as the LM unit. A change of seal material is required to meet Freon 21 compatibility requirements. A pump package has been modified (seal changes only) and run successfully for 3000 hours with Freon 21. The thermal control valve is supplied by Garrett Corporation and has been qualified for the Gemini program. A modification to the wax vernatherm element will be made and will require partial requalification. The Freon boiler will be supplied by Hamilton Standard. It will be tested for high system pressure requirements. Cold plates will be fabricated by Martin Marietta of a plate and serpentine tube design similar to the units developed for the "Prime" program. The quick disconnect will be supplied by Hamilton Standard and will be the same unit as used on LM, except for a Material Change to elastomers. The hand valves will be supplied by Garrett and are the same units as those used on the Apollo CM, except for a seat material change. The accumulator will be supplied by Hamilton Standard. It is the unit used on LM, except for a change in diaphragm material.

Table 4.1.2-III Thermal Control-System Fully Redundant

COMPONENT DATA

COMPONENT	QTY	POTENTIAL SUPPLIER	RE-QUAL	PRIOR USAGE	DELIVERY TIME
RADIATOR	1	MARTIN MARIETTA	YES	SIMILAR TO TIII	10 MO.
PUMP PACKAGE	1	HAMILTON STANDARD	NO	LM (2)	10 MO.
THERMAL CONTROL VALVE	2	GARRETT	PARTIAL	GEMINI	8 MO.
FREON BOILER	1	HAMILTON STANDARD	NO	LM	10 MO.
COLD PLATES	(1)	MARTIN MARIETTA	YES	"PRIME" PROGRAM	10 MO.
QUICK DISCONNECT	1	HAMILTON STANDARD	NO	LM	6 MO.
HAND VALVE	4	GARRETT	NO	APOLLO CM	8 MO.
ACCUMULATOR	2	HAMILTON STANDARD	PARTIAL	LM	10 MO. (3)

NOTES:

(1) TO BE DETERMINED.

(2) LM PACKAGE RUN 3000 HRS. ON FREON 21 WITH STATIC "O" RING MATERIAL CHANGE ONLY.

(3) DIAPHRAGM MATERIAL MUST BE CHANGED FOR FREON 21 COMPATIBILITY.

Table 4.1.2-III Thermal Control-System, Fully Redundant

4.1.3 Pressurization

4.1.3.1 Summary - A carrier pressurization trade study has been completed. (Refer to PR 29-8, Carrier Pressurization Study). This study considered an unpressurized carrier as well as a pressurized version with two modes of pressurization; namely, continuous and intermittent pressurization. Parameters considered include crew and experiment aspects of pressurization, as well as oxygen utilization and system weight comparisons. The pressurized carrier, using a continuous pressurization mode has been selected. An option of intermittent mode operation can be utilized if warranted by experiment oxygen compatibility requirements.

4.1.3.2 Oxygen Requirements - Oxygen requirements for the continuously pressurized carrier are based on the following assumptions:

Continuous pressurization for 12.5 days

Pressure level is 5.0 psia (nominal)

Leakage of docking adapter interface is 2.4 lb/day

Leakage of carrier (through windows and seals) is 1.0 lb/day

Leakage of NAA scientific airlock is not included

These conditions result in an oxygen requirement of 50 lbs as compared to 58 lbs for the intermittent pressurization/vent configuration. It is assumed that carrier pressurization will be accomplished by oxygen supplied from the CM. In the event the CM cannot provide the required gas, an independent carrier system will be required as shown in Figure 4.1.3-1. The hardware for this system is listed in Table 4.1.3-I.

4.1.3.3 Carrier CM Interface - The Block II CM/LM 4-Way pressurization valve and the CM hatch equalization valve will be used to assure pressure equalization across the CM pressure-thermal hatch. The 4-way valve will also be used to vent the carrier prior to initiation of the CM/carrier pyro separation device. A relief valve will be provided in the carrier for overpressure protection.

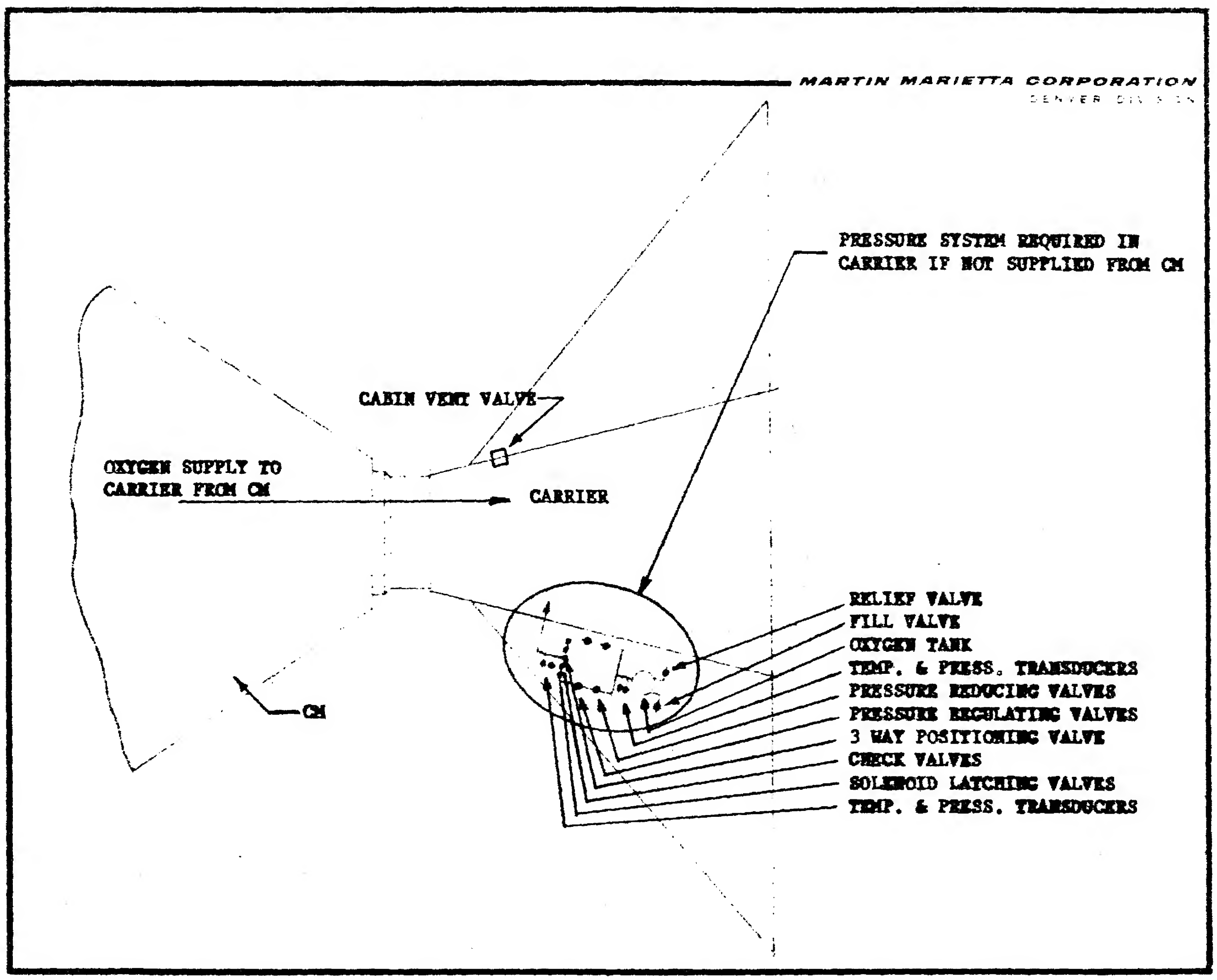

Figure 4.1.3-1, Oxygen Supply System for Pressurization

Table 4.1.3-I Independent Oxygen Pressurization Requirements

OXYGEN WEIGHT	
CONTINUOUS PRESSURIZATION FOR 12.5 DAYS	50.0 LBS
INTERMITTENT PRESSURIZATION (10 PRESSURIZATIONS PLUS 40 HRS FOR EXPERIMENTS & DATA RETRIEVAL)	58.0 LBS
HARDWARE WEIGHT	
RELIEF VALVE	
FILL VALVE	
OXYGEN TANK	
PRESSURE TRANSDUCER (TANK)	
TEMPERATURE TRANSDUCER (TANK)	
PRESSURE REDUCING VALVES	
PRESSURE REGULATING VALVES	
SOLENOID LATCHING VALVES	
CHECK VALVES	
3 WAY HAND POSITIONING VALVE	
PRESSURE TRANSDUCER (CARRIER)	
TEMPERATURE TRANSDUCER (CARRIER)	
VENT RELIEF VALVE (CARRIER CABIN VENT VALVE)	
TOTAL WEIGHT FOR HARDWARE	61.0 LBS
STRUCTURAL MOUNTS LINES AND FITTINGS	25.0 LBS
TOTAL WEIGHT	
CONTINUOUS PRESSURIZATION SYSTEM	136.0 LBS
INTERMITTENT PRESSURIZATION SYSTEM	144.0 LBS

4.1.4 Display and Control

4.1.4.1 Requirements - The control and monitoring of the AAP-1A experiments and supporting subsystems will be provided by a display and control system. This system is essential for the successful operation of AAP-1A experiments, since the mission philosophy is based on the astronaut's ability to effeciently control, monitor and respond, not only to the prescribed flight plan, but to unpredictable situations.

The requirements and ground rules imposed on the design of this system are summarized as follows:

- The display and control system must be designed to fulfill the AAP-1A mission requirements with minimum cost.
- All displays and controls must be essential for mission success. Displays requiring no action by the astronaut will not be provided on the panel.
- The system will have minimum impact on the present Apollo system.
- It will be mandatory that proven designs and qualified hardware be used throughout the design.
- The crew station for the 1A mission will be in the command module.
- The full CM/carrier 74 pin interface capability must be made available. This will be accomplished by removing the present connectors and mating the control panel wiring after SLA separation.
- The separate display unit shown in Figure 4.1.4-1 has been designed for S017/T004 (X-Ray Astronomy and Frog Otolith) and will be used as provided by the experimenter.
- It is assumed that the hardlines necessary for operation of S017 can be time shared with other experiments.

Analysis of the experiment and subsystem requirements (Study Report PR 29-33, Display and Control Studies) indicates that the primary function of the system will be to initiate control signals and to provide status indications. The control capability will be provided by a logic address system and status

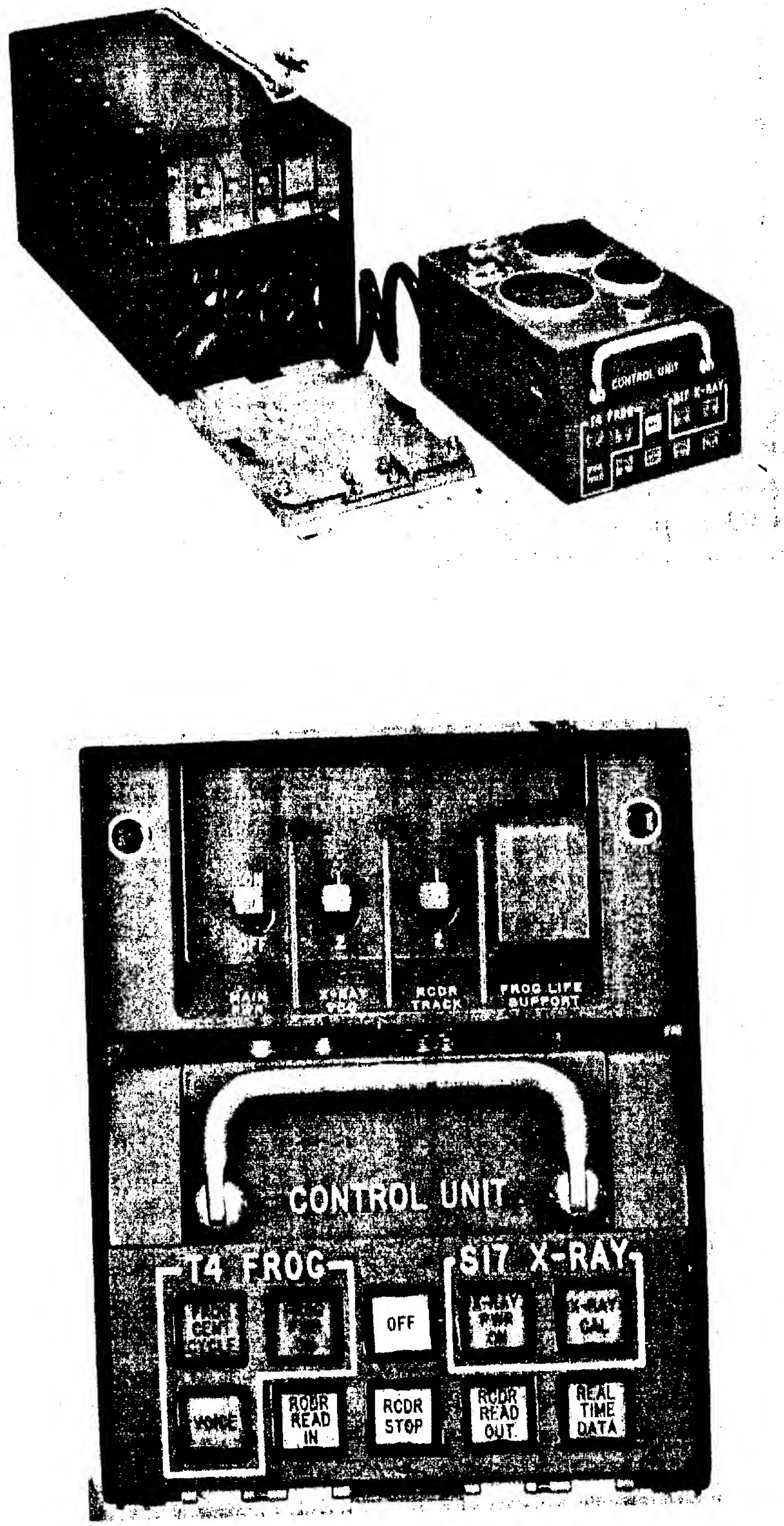

Figure 4.1.4-1, S017/T004 Display and Control Unit

4.1.4.1

signals will be provided by a multiplex system together with time shared hardlines.

4.1.4.2 Control System - All control signals will be generated through the logic system, except for electrical power and thermal control signals. These critical control signals will be hardwired to the carrier.

The logic address signals will be initiated either from individual controls or from a keyboard located on the panel. Where individual control signals are used, the signal will be encoded into a 7-bit binary signal prior to transmission. Where the keyboard is used, the proper code will be entered and then shifted to the carrier as a parallel digital address.

Coded command signals will be routed to the control and distribution unit, where the coded address will be decoded. The decoded signal will then drive a magnetic latching relay. The output of the relay is the desired control signal. In cases where a continuous signal is not required, the latching relay will be replaced by a standard relay, or the control signal will be routed directly to the subsystem or experiment.

4.1.4.3 Control Status System - As was pointed out in Study Report No. PR 29-33, a logic address system solves one problem, but creates another. This problem is that of defining the control system status. If all control signals were hardlined to the carrier, this problem is solved by using switch positions as indications of "on" and "off". However, with a logic system, this approach cannot be used, since all commands are momentary. The astronaut must know exactly what the state of the control system is at all times. The only way that this information can be conveyed is to provide indicators on the panel that actually monitor control signals in the carrier. The approach that will be used is to provide one indicator for complementary functions (on/off type).

The problem of transmitting status signals from the carrier to the CM will be solved, in part, by using a multiplex system. This system will sample 32 signals sequentially using binary counters and logic gates, located in the carrier and on the panel. The sampled status signal will set flip-flops on the panel, which in turn will either energize or de-energize the proper indicator. The 32 status indications are provided

4.1.4.4

over three lines from the carrier. Additional status capability will be provided by time sharing 20 of the hard-lines provided for the S017 experiment.

4.1.4.4 Time Share Capability - Time sharing the lines to S017 was selected as a means of further enlarging system capability. This approach was based on the fact that S017 can operate only when other experiments are off. The lines will be switched in the carrier and on the panel by means of push button switches located near the keyboard matrix. In the normal position signals from S017 will be routed to the experimenter panel and in the other position Standard Application functions requiring hardline capability will be routed to the panel.

4.1.4.5 Analog Call-Up System - Interrogation of analog signals will be performed through use of an analog call-up system. This capability will be provided by the control logic system, a series of selectable relays and a dual movement meter located on the panel. A pair of analog signals will be addressable from the keyboard. When this address is sent to the carrier system, the proper analog signals will be transmitted to the panel meter. The selected signals will be displayed, until additional signals are required.

4.1.4.6 Caution and Warning Capability - At the present time, firm requirements for caution and warning signals have not been established. However, analyses and studies have assumed that these signals will be required in the future. Therefore, four interface pins have been allocated to caution and warning signals. The assumption is that two signals will be required and that each will require redundant wiring.

4.1.4.7 Up-Data Link Capability - The capability to dump recorded data and control T004 during astronaut sleep cycles will be provided, by hardwiring up-data commands to the control and distribution system. The resulting command signals will then control T004 and the recorder/transmitter operational modes. The control panel will include an override control, which will allow the astronaut the option of enabling the up-data commands.

4.1.4.8 Control Panel - The control panel will include the features of functional ease and system flexibility. These will be derived by using individual control switches and the logic keyboard.

4.1.4.8

The philosophy to be followed is reflected in the preliminary mockup shown in Figure 4.1.4-2. Individual momentary action switches will, in general, be used to control primary functions such as "Operate". The keyboard will be used to initiate secondary functions and to call-up analog signals. The controls for each experiment will be located in defined areas, as shown in Figure 4.1.4-2. The supporting subsystem controls will be located in the most accessible areas, since these are required throughout the mission to direct system operations. The panel will be portable, but will also include provisions for hard mounting. The capability for lighting the working area will be provided along with a three-position brightness selector control. It should be pointed out that while the panel will be designed using qualified components, these components will be of the Block I type. Therefore, electro luminescent lighting will not be used in the design. This decision is based on the fact that 115 volts, 400 Hz will not be available at the panel.

4.1.4.9 System Description - A block diagram of the proposed system is shown in Figure 4.1.4-3. The system will consist of the two control panels and the control and distribution center. The control and distribution center will contain the total carrier capability for decoding, multiplexing and routing of control and display signals. The two portable panels will be stowed in the carrier during boost and then installed in the CM after SLA separation. The system will not include capability for a CRT. This decision is based on the following factors:

- Coax will not be provided across the CM/carrier interface.
- Lead time for delivery of a qualified CRT is excessive.
- The unit would require a separate fixed installation.

4.1.4.10 Summary - The proposed system was selected as a result of Study Report No. PR 29-33, Display and Control Studies. The conclusions of this report have been significantly based on the 74-pin constraint. This single factor led to the system using logic (keyboard) control and multiplexing as recommended in KF-30-174, Comments and Recommendations on ATM Systems, from R. F. Thompson to NASA-MSFC, as well as from a practical engineering standpoint, a better approach

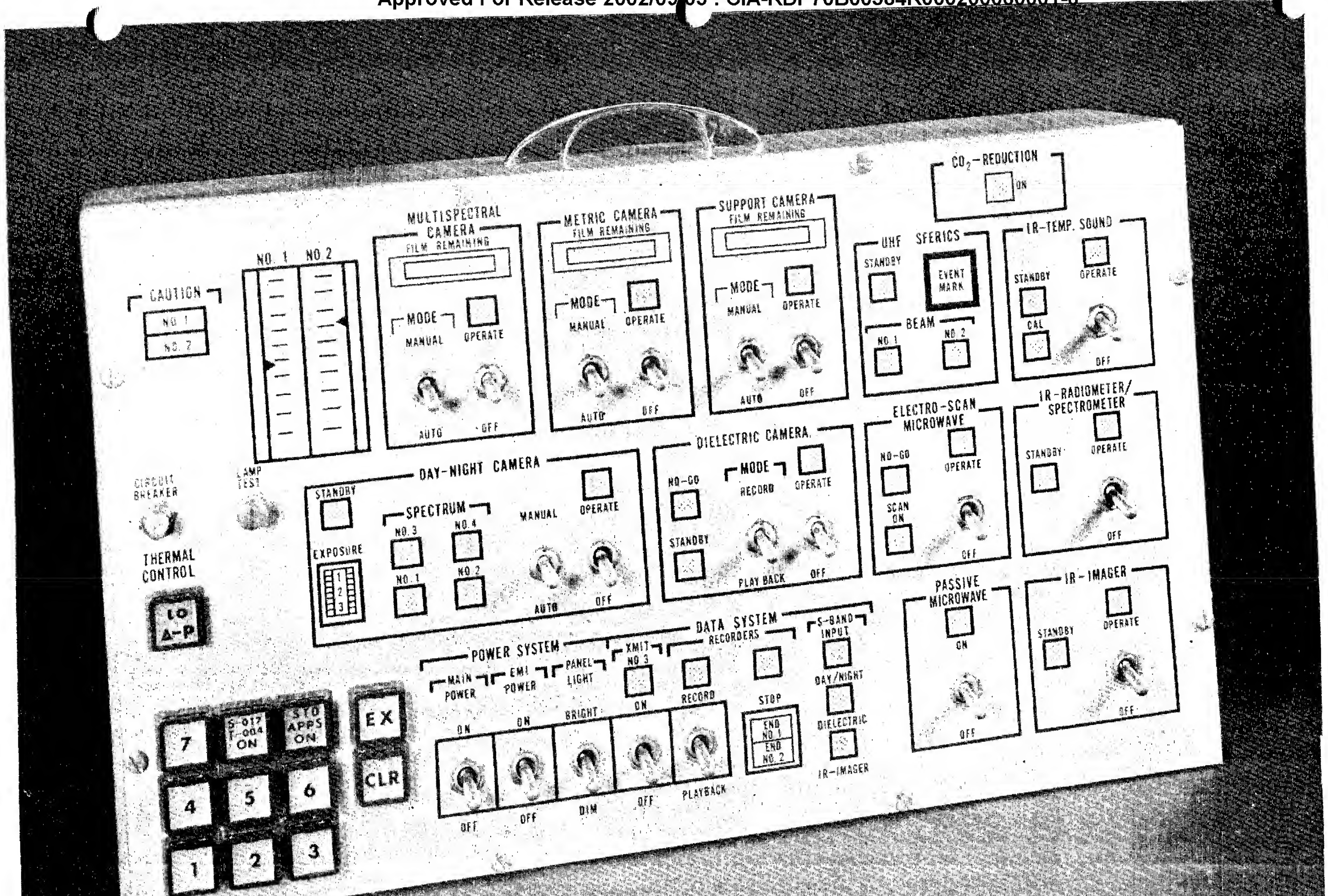

Figure 4.1.4-2

Preliminary Mockup of Control Panel

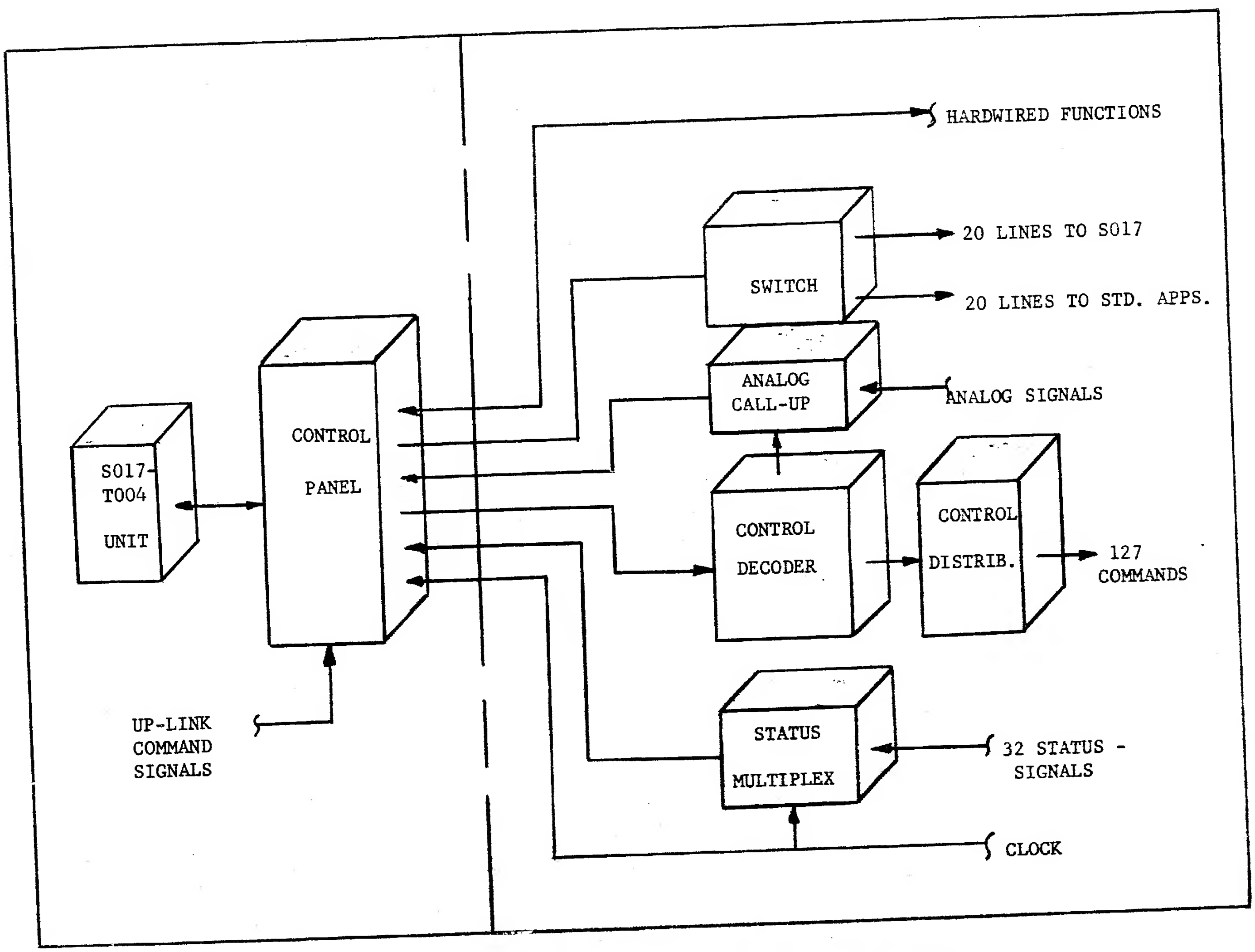

Figure 4.1.4-3, Block Diagram of [illegible] Control System

4.1.4.10

would be found in the use of a direct system. This approach, although simpler and less costly, would require a modification to the CM/carrier electrical interface.

4.1.5 Electrical Power and Distribution Subsystem (EPDS)

4.1.5.1 General - The electrical power and distribution system (EPDS) provides power generation and distribution to experiments and subsystems. The EPDS design approach is to provide redundancy such that no single component failure will cause loss of power to any experiment or subsystem. The EPDS uses space qualified hardware to the maximum extent practicable in order to minimize cost, technical risk and to reduce the time required to obtain flight hardware.

4.1.5.2 DC Power Generation - Batteries are used in the EPDS to provide DC power. Justification for the decision to use batteries may be found in Trade Study Report PR 29-20, Electrical Power, Fuel Cells vs Batteries. There are two types of power distribution busses in the EPDS. These are the Main Bus and the EMI Sensitive Equipment Bus. Each of these bus types will be discussed separately. It should be noted that EMI characteristics have not yet been well enough defined to determine which specific loads will be connected to the Main Busses and which will be connected to EMI Sensitive Equipment Busses. Therefore, the location of the seven batteries may change as EMI characteristics are defined.

4.1.5.2.1 Main Bus - The main busses (Main Bus "A" and Main Bus "B" of Fig. 4.1.5-1) provide DC power to the Data Management System, Thermal Control System, Display and Control Panel, Carrier Lighting, static inverters, and experiments which generate excessive EMI. The two main busses are in parallel and act as redundant power distribution points for all main bus loads. Two motor driven switches are used to apply power to the main busses and either bus will be capable of providing necessary power in the event of failure of the other bus.

4.1.5.2.2 EMI Sensitive Equipment Bus - The two EMI Sensitive Equipment Busses (Ref. Fig. 4.1.5-1) provide DC power to experiments and subsystems which are susceptible to EMI and/or generate negligible EMI. The two busses are in parallel with each other and will act as redundant power distribution points for all EMI sensitive loads. Two motor driven switches are used to apply power to the busses and either bus will be capable of providing necessary power in the event of failure of the other bus.

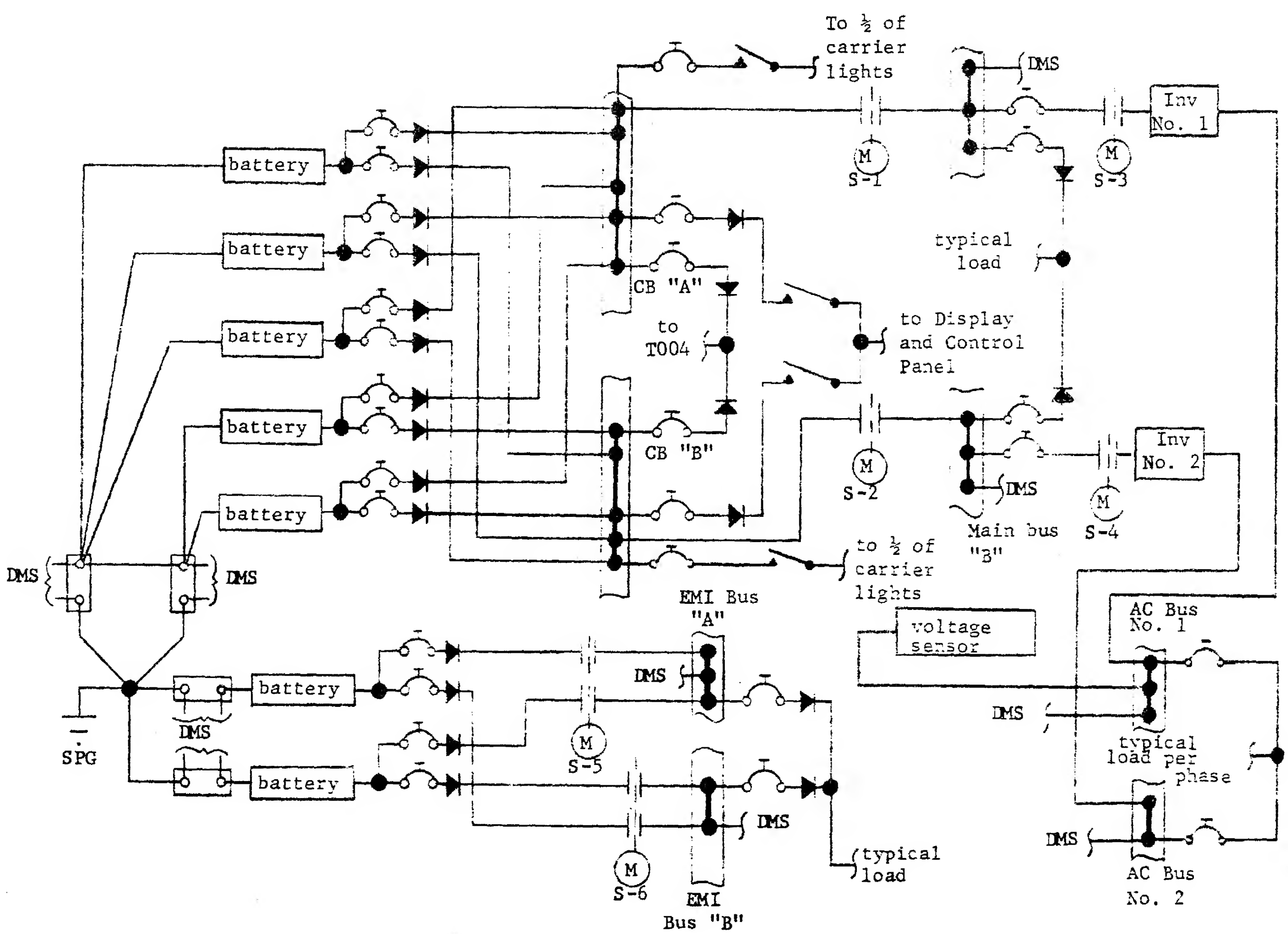

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Figure 4.1.5-1 EPDS Schematic

4.1.5.3 DC Power Distribution - DC power distribution shall be provided by a two wire system with the negative return isolated from structure except at the single point ground (SPG). High level and low level loads shall not share the same negative return wiring as far as practicable. The SPG for the EPDS will be on the carrier and carrier power shall be isolated from CSM power.

4.1.5.4 DC Power Capacity - The EPDS has the capability of providing a minimum of 78.4 kilowatt hours (KWH) of energy. This capacity is based on using seven (7) 400 ampere hour, nominal 28 volt DC batteries. The total energy requirement is documented in Trade Study Report PR 29-21, Power Profile. Since the total energy requirement is approximately 59 KWH, the EPDS provides a spare capacity of approximately 20 KWH which results in approximately one spare battery in the Main Bus battery bank and one spare battery in the EMI Sensitive Equipment Bus battery bank.

4.1.5.5 AC Power - AC power is required for the Data Management System and for Experiment No. E06-7. Two inverters will be provided in the EPDS. One inverter will receive power from Main Bus "A", and the other will receive power from Main Bus "B". Only one inverter will operate at any time and the secondary inverter will automatically be turned on in the event of an over-voltage or an undervoltage on the output of the primary inverter.

4.1.5.6 GSE Requirements - During checkout, ground power will be provided to the EPDS through manually disconnected umbilicals. GSE will have the same capability of controlling the EPDS switches as the Display and Control panel would have during flight conditions. A GSE tool will be used to verify integrity of isolation diodes during subsystem testing.

4.1.5.7 EPDS Operation - In order to maximize reliability in the EPDS, redundancy is initiated as close as possible to the output terminals of the batteries. Isolation is maintained between busses to prevent any single component malfunction from causing loss of power on both busses. Battery circuit breakers are located as close to the battery as practicable so as to minimize the terminations between the battery and the circuit breakers. This minimizes the number of points that could fault to structure

and discharge a battery without opening a circuit breaker. For this reason, the isolation diodes are placed "downstream" from the battery circuit breakers. The purpose of the isolation diodes is to prevent a short in one battery from loading parallel batteries and discharging them prematurely. Main busses A and B and EMI Sensitive Equipment busses A and B will not be energized until the motor driven switches S-1, S-2, S-5, and S-6 are closed through the Display and Control Panel after docking. All four switches will be closed during carrier operation and in the event of failure of one bus, the redundant bus is already energized and would supply uninterrupted power to all loads.

Since the main busses will not be energized until after docking is complete and since the Frog Otolith experiment (T004) requires power from prior to liftoff, provisions are made to apply power to the Frog Otolith experiment when the frog is installed. Application of power is accomplished as follows:

a. Circuit breakers CB "A" and CB "B" are opened;

b. T004 is installed and electrically connected;

c. Circuit breakers CB "A" and CB "B" are closed.

The normally closed contacts of a magnetic latching relay are in series with the T004 power wiring. Therefore, when circuit breakers A and B are closed, power is applied to T004. The relay contact will be opened via the Display and Control Panel upon completion of the T004 experiment.

Switches are provided to prevent application of main bus power to the Display and Control panel until after the panel has been transferred to the CM and electrically connected.

Two inverters are used to provide AC power. Only one inverter (No. I) will normally be operating. It will be energized by closing of motor driven switch S-3 via the Display and Control Panel. In the event of overvoltage or undervoltage on the inverter output, the voltage sensor will issue a signal which will automatically open switch S-3 and then close switch S-4. This will remove power from inverter No. I and apply power to inverter No. II. Inverter No. II will then assume all AC loads.

4.1.5.8 EPDS Hardware - The approach on selection of hardware has been to use all space qualified hardware. This results in reduced cost, limited testing requirements and reduced lead time for hardware availability. Table 4.1.5-I summarizes the major components used in the EPDS along with probable suppliers, prior usage and anticipated modifications.

Component	Supplier	Prior Usage	Mod Req
Battery	Eagle-Picher	LM Descent	Cell Tap Change and testing to AAP-1A power profile
Inverter	Bendix	Gemini Launch Vehicle	None
Shunt	Janco	Titan III	None
Motor Driven Switch	Kinetics	Titan III	None
Undervoltage/Overvoltage Sensor	Autonetics	Apollo	May require voltage trip level change
Circuit Breaker	Mechanical Products	Apollo	None
Diode	Westinghouse	Apollo	None
Harness Assy Set	Martin Marietta	New	New
Lighting Control Panel	Martin Marietta	New	New
Circuit Breaker Panel	Martin Marietta	New	New
Carrier Lights	Grimes or Microdot	Airlock Module	None

Table 4.1.5-I EPDS Major Components

4.1.5.8.1 Battery - The steady state voltage limits at the load terminals has been established at 25 to 32 volts DC. In order to maintain these voltage limits at equipment terminals, distribution system losses must be considered. Distribution system losses are the result of isolation diodes, switch contact, circuit breakers and wiring. These losses have been determined to be approximately 4 volts maximum and 2 volts minimum. This establishes the battery voltage limits at 29.0 to 34.0 volts DC.

In order to provide the necessary electrical energy at the minimum cost and weight, only qualified silver zinc batteries were considered. The 400 ampere hour battery used in the LM Descent Module was found to be the most acceptable for the EPDS application. This battery contains 20 cells and presently provides outputs from the twentieth cell and another output from a tap on the seventeenth cell. The tap will be moved from the seventeenth cell to the nineteenth cell for use in the EPDS. Some cell testing will be required to verify that cell voltages remain within the limits of 1.53 to 1.79 volts per cell when tested to the Flight AAP-1A power profile. For the steady state current requirements presently identified for the EPDS (0.4 to 10 amperes per battery), it is anticipated that the cells will remain within the limits of 1.53 to 1.79 volts DC giving a nineteen cell battery voltage of 29 to 34 volts DC. The batteries weight approximately 140 pounds each, have an activated stand time of 30 days minimum and a minimum capacity of 400 ampere hours.

4.1.5.8.2 Inverter - The S-Band portion of the Data Management System, and experiment number E06-7 require AC power. All AC power required is 3 phase, 400 cycle, 115/200 volts. The S-Band Power Amplifier load is 90 watts, the S-Band Transmitter load is 8 watts and the experiment E06-7 load is 2 watts. This results in an AC load range of 0 to 100 watts. Assuming a minimum power factor of 0.7, the volt ampere requirement on the inverter varies from 0 to 143 volt amperes.

The Apollo inverter and the Gemini Launch Vehicle inverters were both considered for use in the EPDS. However, due to lighter weight and lower cost, the Gemini inverter was selected. The characteristics of the inverter are as follows:

Voltage - 115/200 volts rms

Voltage Regulation - $\pm$ 1.5%

Frequency - 400 H_Z

Frequency Regulation - ± 1%

Capacity - 500 volt amperes

Phase Displacement - 120 ± 2 degrees.

4.1.5.8.3 Shunts - Shunts will be used in the battery returns to provide battery current information. The shunt selected for this application is the Martin Standard 92D18 shunt used on the Titan III family of boosters. The 92D18 is a 50 millivolt shunt and is available in 5 and 50 ampere ratings.

4.1.5.8.4 Motor Drive Switch - The motor driven switch must be capable of carrying up to 50 amperes steady state and transient loads of approximately 100 amperes. A two pole, single throw, 200 ampere, motor driven switch used on the Titan family of boosters will be used for this application.

4.1.5.8.5 Undervoltage/Overvoltage Sensor - A voltage sensor will be used on each phase of the primary static inverter output. In the event of an undervoltage or an overvoltage, the primary inverter will automatically be turned off and the secondary inverter turned on. The Autonetics voltage sensor used on Apollo inverter outputs will be used for this application. The sensor will trip at an overvoltage of approximately 128 volts and an undervoltage of approximately 110 volts. The nominal inverter output voltage is 115 volts ± 1.5%.

4.1.5.8.6 Circuit Breaker - Circuit breakers will be used on all loads to prevent damage to wiring and components in the event of an overcurrent. The Mechanical Product series 700-69 and 1500-69 circuit breakers are available in 1 to 50 ampere range which would satisfy all EPDS requirements.

4.1.5.8.7 Diode - Isolation diodes will be used in each battery output to prevent a fault in one battery from discharging other batteries in the EPDS. These diodes will carry steady state currents of approximately 10 amperes and peak currents of approximately 20 amperes. The diode selected for use in this application is the Westinghouse 1N3909. This diode has a continuous rating of 35 amperes and can withstand a surge current of 135 amperes for 2 seconds.

4.1.5.8.8 Lighting Control Panel - A lighting control panel will be provided in the carrier to permit the astronaut to turn on carrier lighting prior to entering the carrier. The panel will contain two toggle switches for lighting, each of which will control half of the lights in the carrier. The panel will contain two other switches which will be used to apply power to the Display and Control Panel after the panel has been moved to the CM and connected to the Display and Control cordage.

4.1.5.8.9 Circuit Breaker Panel - Circuit breaker panels will contain all EPDS circuit breakers and will be physically located outside the pressurized area of the carrier. Due to circuit redundancy, the circuit breakers will not require resetting during flight.

4.1.5.8.10 Harness Assembly Set - The harness assembly set provides all cordage required for the carrier and will consist of wiring, connectors and terminal boards. In order to provide cable harness at minimum cost, maximum flexibility and to meet delivery schedules, the laced (tied) type of harness assembly will be used. The laced cable is very adaptable to engineering design changes since it does not depend on availability of molds, boots, jackets, etc. This type of harness also permits in-house fabrication using existing Martin manufacturing procedures.

. Wiring - The EPDS will primarily use H-film wire due to its non-flammable properties and its combination of lightweight, small diameter, excellent cold flow resistance and high resistance to physical damage. An example of weight saving using H-film wire is made by comparing it with MMS-E-3932329 lightweight wire. MMS-E-3932329, 22 gauge, 2 conductor shielded wire weighs 0.0237 pounds per foot and 22 gauge, 2 conductor shielded H-film wire weighs 0.0134 pounds per foot.

. Connectors - Poke home type (NAS 1599) miniature circular connectors will be used in the EPDS. This connector uses crimp type contacts which can easily be extracted and reinserted in the event of a design change. Non-flammable, hard vacuum compatible inserts will be used. MIL-C-5015 potted type connectors will be used primarily for batteries where the insert configuration is determined by battery design and is not likely to change.

- Terminal Boards - Two types of terminal boards will be used in the EPDS. One type will be used in the oxygen atmosphere and the other will be used outside the oxygen atmosphere. Inside the oxygen atmosphere, the terminations will use the Deutsch Terminal Junction (TJ) series, or equivalent, using machined teflon sealing plugs over unused receptacle holes. Outside the oxygen atmosphere, the terminations will use the MS 27212 terminal board. This type terminal board will be coated with Dow-Corning RTV-589 or equivalent for moisture protection.

4.1.5.9 Trade Study Summaries

4.1.5.9.1 PR 29-20, Electrical Power, Fuel Cells vs Batteries, dated 31 August 1967 - This trade study report compares cost, weight, and simplicity of a fuel cell system with that of a battery system. The study shows that for an energy of 54 kilowatt-hours, the battery system is simpler, and costs approximately $1,349,430 less than the fuel cell system. The battery system weighs approximately 230 pounds less than the fuel cell system.

4.1.6 Data Management Subsystem - The data management subsystem (DMS) is designed to accept primary experimental and subsystem data for management and control to assure complete recovery of all mission data via real time or delayed transmission using facilities of the Manned Space Flight Network (MSFN). Control, status monitoring, up-data link (UDL) control, and interface configuration with the Apollo Command Module are discussed and explained in Paragraph 4.1.4.

The utilization of Command Module Data Management System capabilities was investigated. The time sharing of the 3 spare scientific voltage controlled sub-carrier oscillator channels of the Command Module's (CM) S-Band System was evaluated. The resultant modification to the CM would be adding 3 coax connectors at the interface and wiring of these three channels from the interface to the S-Band System. In addition, the data timeline is such that the carrier would require transmit time more frequently than the CM's S-Band System could provide. Incorporating carrier data signals into the CM Pulse Code Modulation (PCM) system was reviewed. This method would have required extensive additions of connectors and wiring to the CM/carrier interface. Thereby nullifying the concept of minimum modification to the CM. This approach was therefore considered prohibitive. The ability to utilize the existing CM timing capabilities (Central Timing Equipment-CTE) was also extensively investigated. Trade Study No. PR 29-50, Carrier Timing Technique, was performed resulting in the recommendation that the carrier include its own CTE. This recommendation was predicated upon the carrier not requiring a time up-dating capability and the ability to correlate events and experiments through the use of the CM voice tape recorder, which has CM time included on the recorder, and the carrier recorders, which have carrier CTE time on them.

4.1.6.1 Requirement - The organization of the DMS for the AAP-1A carrier has been controlled by existing known data requirements of the experiments and subsystems, capabilities of the MSFN and availability of hardware capable of satisfying these requirements. The DMS must:

- Provide the capability for monitoring and processing all experiment and subsystem measurements. Table 4.1.6-I outlines the experiment and sub-system data requirements.

TABLE 4.1.6-I, DMS Requirements and Capabilities

Data Requirements

	DIGITAL Input				ANALOG				EVENT (Bi-Level)	SPECIAL Freq.				Digital		Self Cont.
	160 BPS	100 BPS	80 BPS	50 BPS	5 SPS	1 SPS	.4 SPS	.4 SPS	10 SPS	1 SPS	1.5 MHZ	50 KHZ	240 HZ	19 KBPS	1.9 KBPS	
EXPERIMENTS	2	1	1	2	2-65		36			3	1	1	1	1	1	2
SUBSYSTEM					19	21		53	20							
TOTALS	2	1	1	2	2 84	21	36	53	20	3	1	1	1	1	1	2

System Capabilities

PCM SYSTEM

	40 HLA	20 HLA	10 HLA	10 BL	10 BLP	1.25 HLA	1.25 LLA	.416 LLA	.416 24D
Capacity	3	3	6	88	32	96	24	72	24
Data Requirements	2	2	5	23	-	94	22	71	1
Spares	1	1	1	65	32	2	2	1	24

FM MULTIPLEX

8 Channels IRIG 2 thru 9

6 Digital Inputs + time = 7

Spare 1

SPECIAL DIGITAL

23 KBPS Data Train

Record on Tape Recorder No. 2

4.1.6.1

- Provide flexibility in handling the experiment data outputs. These include data channel capacity, frequency response, alternate data collection paths and modes of operation. This flexibility is needed for addition and revisions in the experiments as well as for growth potential.

- Be capable of obtaining data for any sequence of operation during the entire mission life.

- Meet all requirements while maintaining minimum cost per unit.

- Be compatible with the experiment and subsystem data inputs.

- Be capable of accepting control through the UDL incorporated in the CM.

- Utilize as much capability as possible from the experiments or the CM.

- Provide timing or clock pulses to experiments for proper operation or synchronization.

4.1.6.2 Functional Description - The basic design, while meeting the known requirements for the experiments and subsystems, also provides the flexibility for growth resulting from changes in either experiments or subsystems. The system, as configured at the present, is composed of a signal conditioner, 5.12 KBPS PCM System an eight (8) channel FM System, three (3) UHF transmitters, (one of which is relocated from an experiment), two (2) tape recorders (one of which is part of an experiment data handling package) and an S-Band System. Figure 4.1.6-1 (Data Management System - Block Diagram) reflects this configuration.

4.1.6.3 Component Description - The necessity for extreme flexibility, growth and ability to accommodate fast and last minute data requirement revisions resulted in the configuration shown in Figure 4.1.6-1. The major component of the system are as follows:

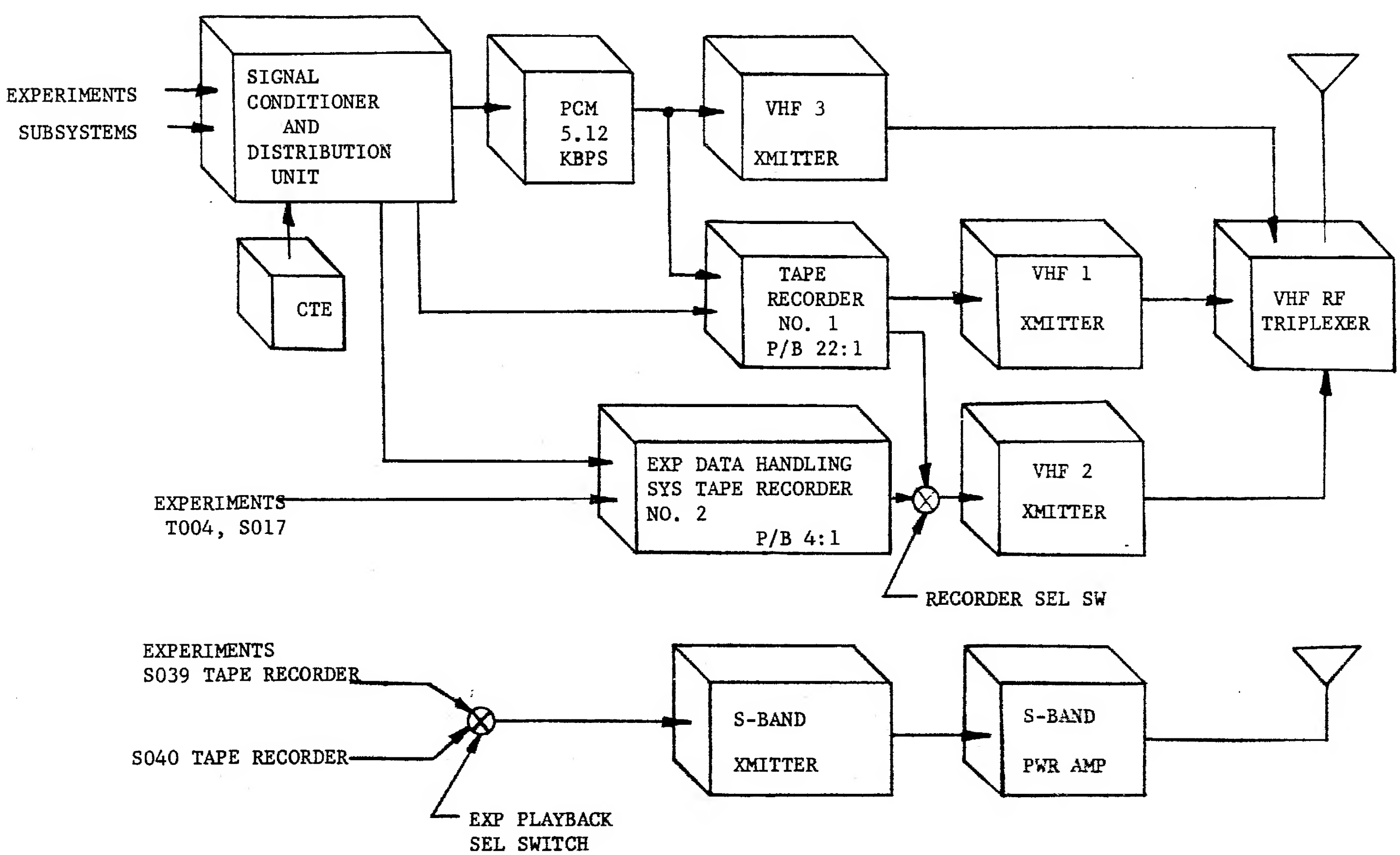


Figure 4.1.6-1 Data Management System Block Diagram

4.1.6.3

- Signal conditioner and distribution unit
- PCM multiplexer-encoder
- Tape recorder/reproducer (Recorder No. 1)
- VHF transmitter system
- Central time equipment
- Modified experiment data handling system (Recorder No. 2)
- S-Band transmitter system
- Support camera

The capability or use of each component is per the following description:

4.1.6.3.1 Signal Conditioner and Distribution Unit - This unit has the requirement to adequately condition experiment and subsystem data signals for application to the PCM encoder and tape recorders. This conditioning will take the form of frequency conversion, voltage attenuation and voltage amplification. All signal distribution will be accomplished from this unit. Necessary parameters such as time of day, or various clock rates will be programmed from this unit. Various experiments present signals to the DMS that cannot be handled in a normal manner. An example of this would be digital signals of 160 BPS. This type of signal will be applied to a voltage controlled sub-carrier oscillator (SCO) complex for conversion to a multi-lexed signal adaptable to the DSE. This SCO system will consist of standard IRIG channels 2-9. In addition, all DMS power supplies, or data switching circuits will be contained within the signal conditioner. The requirement for providing a square wave timing signal needed for camera control will be generated within the signal conditioning unit and distributed to experiments requiring this signal.

4.1.6.3.2 PCM Multiplexer - Encoder - The PCM system proposed for use on the AAP-1A carrier will be the Electro-Magnetic Research (EMR) system that was utilized on the Gemini Program. The system configuration for the carrier will consists of:

4.1.6.3.2

One (1) Programmer

Three (3) Low Level Multiplexers

Two (3) High Level Multiplexers

With this configuration the PCM system will have the capability of encoding the following:

Quantity (Channels)	Samples Per Sec.	Remarks *
3	40	Analog, hi-level
3	20	Analog, hi-level
6	10	Analog, hi-level
96	1.25	Analog, hi-level
24	1.25	Analog, lo-level
72	0.416	Analog, lo-level
88	10	Digital, bi-level
32	10	Digital, bi-level pulse
24	0.416	Digital, Parallel

* Hi-level = 0-5 v
Lo-level = 0-20 mv
Bi-level = 0 = 5 vdc
1 = 15 vdc
Digital = N.A.

The configuration shown has a bit rate of 5.12 KBPS and the format is an 8-bit word. The serial data train of 5.12 KBPS is fed to the input of a tape recorder for storage until such a time that playback and transmission to a MSFN ground station can be accomplished. The configuration also has the ability to provide a serial bit data train of 51.2 KBPS which is applicable only to a transmitter in real time. The present plan is to use only the 5.12 KBPS portion but if data requirements

4.1.6.3.2

develop (for real time only) this capability will be employed.

4.1.6.3.3 Tape Recorder/Reproducer (Recorder No. 1) - This unit will have the ability to accept the output of the PCM system (5.12 KBPS) for storage and a multiplexed signal encompassing all peculiar data signals not processed by the PCM system. The record speed will be 1 7/8 IPS with a playback speed of approximately 41.25 IPS (22:1 ratio) with this tape speed, the recorder can record for 4 hours and play back in 12 minutes. The output is provided to 2 transmitters (FM and PCM) for transmission to the MSFM. Control of the recorder is provided to the crew as well as being integrated into the experiments with which it is associated. The unit being considered was used with the 5.12 KBPS PCM system on the Gemini Program. The ability to record the additional multiplexed signal will be a modification. By the nature of the unit, the delayed transmission will not have the inherent accuracy of the real time transmission. The accuracy of the recorder is a function of its output bit error rate during the reproduce mode of operation. Noise in the form of bit-jitter caused by transport speed variations also adversely affects the overall accuracy of the reproduced signal. These two errors, when combined, normally result in an error rate of approximately one in 10^5 bits. Trade Study Report PR 29-45, Tape Recorder Trade Study, reflects the requirements which influenced the decisions to use more than one recorder for data on the AAP-1A carrier. The additional recorder is to complement the ability of this recorder.

4.1.6.3.4 VHF Transmitter System - The RF system proposed for the AAP-1A carrier consists of three transmitters in the VHF spectrum. The requirements which influenced this arrangement are:

The data collection system must have real time transmission capabilities while transmitting the stored (playback mode) data accumulated on the tape recorder. This resulted in 2 VHF to transmit the tape stored data and 1 VHF for real time. Resulting in 3 VHF transmitters.

The data time line for experiment E06-9A and E06-9B made another VHF link necessary, but the data dump capability permitted time sharing one of the transmitters outlined

4.1.6.3.4

in the preceding paragraph.

Experiments T004 and S017, although having its own data handling system, is time sharing one of the VHF transmitters listed in paragraph 1. The experiment is being modified for this reason. Figure 4.1.6-1, Data Management System - Block Diagram, reflects the VHF system configuration.

The units being considered will have usage on the Saturn launch vehicle, but investigation is being continued to acquire a transmitter which is lighter in weight, uses less power (watts) and has approximately the same output (RF Watts). The tentative identification and use for each transmitter is:

VHF Transmitter No. 1 - used for 5.12 KBPS PCM data train only. The bit rate in the playback mode is approximately 112 KBPS.

VHF Transmitter No. 2 - used on a time sharing basis for signals coming from the tape recorder used for the FM multiplexed (digital) data; data from experiments T004 and S017; and digital data from experiment E06-9A and E06-9B.

VHF Transmitter No. 3 - used only for the real time transmission of the encoder 5.12 KBPS data train.

The output of the VHF transmitters is fed to a triplexer for proper conditioning before application of the combined signals to the carrier VHF antenna system.

4.1.6.3.5 Carrier Central Timing Equipment - The Carrier Central Timing Equipment (CTE) will be used for providing serial and parallel time-of-day signals, and a 512 KHZ clock signal for generation of required syne pulses. The time-of-day signals will interface with certain experiments, and the Carrier PCM Encoder and Carrier FM Tape Recorder (Recorder No. 1). A 512 KHZ clock signal is provided to circuits in the Carrier Signal Conditioning Units for generation of required syne pulses in the experiments and DMS. The serial time-of-day signal is a modified IRIG "B" timing signal. The modification consist of deleting the

4.1.6.3.5

17-bit straight binary seconds of the IRIG "B" code. The parallel time-of-day signal is a 26-bit binary code with 7 bits used for seconds, 7 bits used for minutes, 6 bits used for hours, and 6 bits used for days. This is generated within the CTF. Additional outputs that will be available are 6.4 KHZ square wave, 10 HZ square wave, 1 HZ square wave, and 1 pulse per 10 minutes. Trade Study PR 29-50, Carrier Timing Techniques, defines the known carrier subsystem and experiment timing requirements, and discusses various approaches to satisfying these requirements.

4.1.6.3.6 Modified Experiment Data Handling System - Experiments T004 (Frog Otolith) and S017 (X-Ray Astronomy) have included (as part of the experiment) a data handling system capable of supporting the data requirements of the respective experiments. The data time line is such that the total utilization of this capability would not be realized if the data system were only used for the experiments. The modification of this experiment data handling system precluded the need for an additional DMS tape recorder, thereby effecting a cost saving not only in equipment needed to satisfy other experiment data requirements, but also the time to engineer the installation of the additional recorder. The proposed plans would be to modify the data system so that:

The transmitter, which is included in the control and display unit relocated to the carrier and subsequently use the same frequency assigned to this unit. This plan is necessary to keep the different VHF frequencies to a minimum, prevent extensive runs of cable with RF frequencies on them and keep equipment weight to a minimum.

Modify the data handling package so that additional data could be applied to the tape recorder, other than T004 and S017 data. This modification would be in the form of a digital to frequency converter, outside the data package, and the addition of recorder input switches within the package. The recorder will be capable of accepting a modified 23 KBPS serial train for storage and later transferring it at a 92 KBPS rate (4:1) to a transmitter (VHF No. 2) for transmission to the MSFN.

4.1.6.3.6

The experiment recorder (Recorder No. 2) is a Leach MTR 2110.

4.1.6.3.7 S-Band Transmitter System - The necessity for this additional RF wide band transmission system is attributable to the requirement established by Experiments S039 and S040. These experiments have tape recorders as part of the experiments for data storage and require data transmission to MSFN because of their limited capacity. The data being transmitted is of such high frequency (680 KHZ) that only a UHF system is capable of accommodating this requirement. The proposed S-Band will be installed for this purpose. Maximum bandwidth will be approximately 1.5 MHZ. At present the system will consist of a transmitter (exciter), power amplifier and antenna. Studies will be conducted to determine the number of antennae needed.

4.1.6.3.8 Support Camera System - Various experiments planned for use on the carrier require that photographic ground coverage from the spacecraft be obtained for data correlation. Some of these same experiments also require attitude determination information. Trade Study PR 29-28, Support Camera Selection, reviewed the support camera requirements of the Group 1 and Group 2 experiments. The recommendation of this trade study was to provide a support camera (Hycon HG-491) for daylight passages with night support camera coverage being supplied with the Day/Night Camera. Attitude information would be obtained from the G&N system.

4.1.6.4 Operating Modes - The systemin its present configuration has the ability to operate in the following modes:

Transmit -

a. Real time VHF No. 3 and delayed VHF No. 2 (using inputs from Experiments T004, E06-9 or S017 for VHF No. 2 from tape recorder No. 2). Delayed S-Band for experiment S039 and S040.

b. Delayed VHF No. 1 and delayed VHF No. 2 (this mode plays back tape recorder No. 1 only). Delayed S-Band for experiment S039 and S040.

4.1.6.4

c. Delayed VHF No. 1, delayed VHF No. 2 and real time No. 3. (This condition plays back Recorder No. 1 while transmitting real time the output of the 5.12 KBPS encoder). Delayed S-Band for experiment S039 or S040.

Recorded -

a. Recorder No. 1: All output data from the 5.12 KBPS PCM and 8 channel FM Multiplexed signal from signal conditioner (experiment digital data).

Recorder No. 2: All data from the T004 and S017 experiments.

b. Recorder No. 1: (same as 1) above)

Recorder No. 2: All digital data eminating from experiment No. E06-9A/9B only.

c. Each recorder is capable of individual operation, as a function of the particular experiment it is associated with.

4.1.6.5 Data Storage Requirements - The present DMS configuration has a record capability of four (4) hours for Recorder No. 1 and 32 minutes for Recorder No. 2. The data record requirement for a condition that represents the worst position (ground track) of the vehicle, with respect to MSFN, will necessitate 85 minutes of record time on Recorder No. 1 and 30 minutes of record time on Recorder No. 2. It will take 12 minutes of MSFN time for transfer of this stored data via the VHF link. Trade Study No. PR 29-47, Data Bandwidth Utilization, reviews the MSFN and its ability to satisfy the carrier RF requirements while also accommodating the CM requirements.

4.1.6.6 Study Reports - During the study phase, the following Trade Study Reports were prepared:

PR 29-44 - PCM Encoder Review - This report reviewed the availability of a PCM system capable of meeting the anticipated requirements of the AAP-1A carrier, the results indicated the same encoder system used on the

4.1.6.6

Gemini Program would promote the necessary capacity to fulfill the known data requirements. The vendor for this unit is EMR.

PR 29-45 - Tape Recorder Trade Study - This study was an investigation to determine the DSE needed on the vehicle. Results precluded use of only one recorder. The plan is to use one experiment recorder on a time share basis, and install one new recorder for a combination of PCM and FM data.

PR 29-47 - Data Bandwidth Utilization - This study explores the problems involved in transmitting wideband data over an S-band telemetry link. An anlytical technique is developed using a group of sinusoidal signals to represent the complex wideband signal. Sideband amplitudes and RF spectrum envelopes are calculated for a low-pass-filtered signal with two values of carrier deviation, and for a band limited signal. The feasibility of frequency multiplexing other data is evaluated, and transmitter power requirements are calculated. It is concluded that transmission of such a signal is feasible, and that multiplexing of PCM data on the same carrier is possible. Recommended operating parameters are given for the transmitter and ground station.

PR 29-28 - Support Camera Selection - A review of the support camera and attitude requirements was made for Group 1 and Group 2 experiments. Two approaches were investigated for satisfaction of the experiment requirements. Approach alternate 1 selected a Hycon HG-491 as the support camera for daytime coverage, and the Day/Night Camera as the support camera for nighttime coverage. The required attitude information would be obtained from the G&N system in the spacecraft. Approach alternate 2 slected a Hycon HG-490 as the support camera for daytime coverage, and the Day/Night Camera as the support camera for nighttime coverage. A Stellar Camera was selected to obtain the required attitude information. This report recommends that the alternate 1 approach be selected for the baseline.

4.1.6.6

PR 29-50 - Carrier Timing Techniques - This study report explores four different approaches that could be taken to provide time-of-day signals in the carrier. These approaches are (1) use the Apollo CTE (2) obtain timing from the Apollo 51.2 KHZ PCM signal, (3) use a carrier CTE, and (4) design and develop a timing unit. It was concluded that a CTE should be used on the carrier to satisfy all the experiment and sub-system requirements.

4.1.6.7 Source Identification - The most probable selectees for the DMS hardware items are shown in Table 4.1.6-11.

TABLE 4.1.6-II Data Management System - Major Components

COMPONENT	VENDOR	PRIOR USAGE	MODIFICATIONS
Signal Conditioner & Distribution Unit	MMC	(To be Qualified)	New
Central Timing Equipment	General Tire	Apollo - Block II	None
PCM (5.12 KBPS)	EMR	Gemini	None
Tape Recorder	RCA	Gemini	None
VHF Transmitter	IERC	Apollo ATM	None
S-Band Transmitter	Motorola	Apollo	Reduce Complexity (1 Transmitter Required)
S-Band Power Amplifier	Collins	Apollo	None
VHF RF Multiplexer	Rantec	Apollo	Freq. Change
VHF Antenna	MMC	To be Qualified	New
S-Band Antenna	MMC	To be Qualified	New
Experiment T004/S017 Data Handling System	GFE	--	Rework system to accept external signals and controls for multi-use purpose
Support Camera	Hycon	To be Qualified	None

4.1.7 Attitude Control and Pointing

4.1.7.1 Requirements and Constraints - Sixteen of the experiments require orientation control. The pointing accuracy and angular rate requirements for these experiments are tabulated in Table 4.1.7-1. These pointing and rate requirements are in turn imposed on the vehicle because all the experiments are hard mounted to the vehicle, i.e., they are not de-coupled from the vehicle by electronic or mechanical gimbal techniques.

The experiments in the table are grouped according to the type of control required. The groups are earth resources, solar, stellar, and manual navigation. Experiments not listed in the table have no pointing requirements. The only other control requirements are to keep the vehicle rates at a reasonable level during the remainder of the mission. The earth resources experiments must be continuously aligned to an earth centered coordinate frame, i.e., the vehicle must be controlled in three axes so that the experiments are pointed along the nadir and constrained in azimuth. The solar experiment must be controlled in two axes to the sun line, but has no orientation requirements about the sun line. The stellar experiments require control to the star line with no restriction to rotation about the star line. In addition, the stellar experiments require frequent maneuvers to acquire and align to several stars. The manual navigation experiments require vehicle re-orientation to bring appropriate targets within the field-of-view of the spacecraft windows. As the table shows, over half of the experiment requires local vertical control to accuracies ranging from 1.5 to 10 degrees.

Some experiments, notably the metric camera, require a knowledge of the experiment line of sight to an accuracy of 0.5 deg. or better. The metric camera is supported by a set of stellar cameras which will provide concurrent star field data to satisfy this requirement.

TABLE 4.1.7-I ATTITUDE CONTROL REQUIREMENTS

EXPERIMENT		DESIRED ATTITUDE ACCURACY (DEGREES)	MAX. RATE (DEG/SEC)
LOCAL VERTICAL GROUP (EARTH RESOURCES)			
S039	DAY-NIGHT CAMERA	10	NORMAL LIMIT CYCLE
S040	DIELECTRIC TAPE CAMERA	10	NORMAL LIMIT CYCLE
S043	IR TEMPERATURE SOUNDING	5	NORMAL LIMIT CYCLE
S048	UHF SFERICS	5	N/A
	METRIC CAMERA	1.5	.05
	MULTISPECTRAL CAMERA	1.5	.03
	WIDE RANGE IMAGER	1.5	NORMAL LIMIT CYCLE
	IR RADIOMETER	1.5	1
	IR SPECTROMETER	1.5	1
S044A	SCANNED MICROWAVE RADIOMETER	5	NORMAL LIMIT CYCLE
S016	TRAPPED PARTICLE ASYMMETRY	2	N/A
SOLAR GROUP			
S020	XUV SOLAR PHOTOGRAPHY	0.25	MINIMIZE
STELLAR GROUP			
S017	X-RAY ASTRONOMY	0.5	0.05
S019	UV STELLAR ASTRONOMY	0.25	MINIMIZE
MANUAL NAVIGATION GROUP			
T002	MANUAL NAVIATION SIGHTINGS	5	0.25
D009	SIMPLE NAVIGATION	5	1

4.1.7.1 (Continued)

S016 is not an earth resources experiment, but does require an essentially local vertical orientation during passes through the South Atlantic Anomaly. In addition, the sensor must be rotated about an axis corresponding to the radius vector from Earth's center in a manner that will maintain the experiment approximately normal to Earth's magnetic field.

A maximum of 281 pounds of RCS propellant has been allocated for attitude control and pointing system usage after meeting requirements for transposition and docking, SPS thrusting, and de-orbit backup. Other constraints are to minimize CSM modifications, minimize need for crew involvement, minimize weight and power, and maximize reliability. Maximum use must be made of qualified shelf hardware because of the tight schedule.

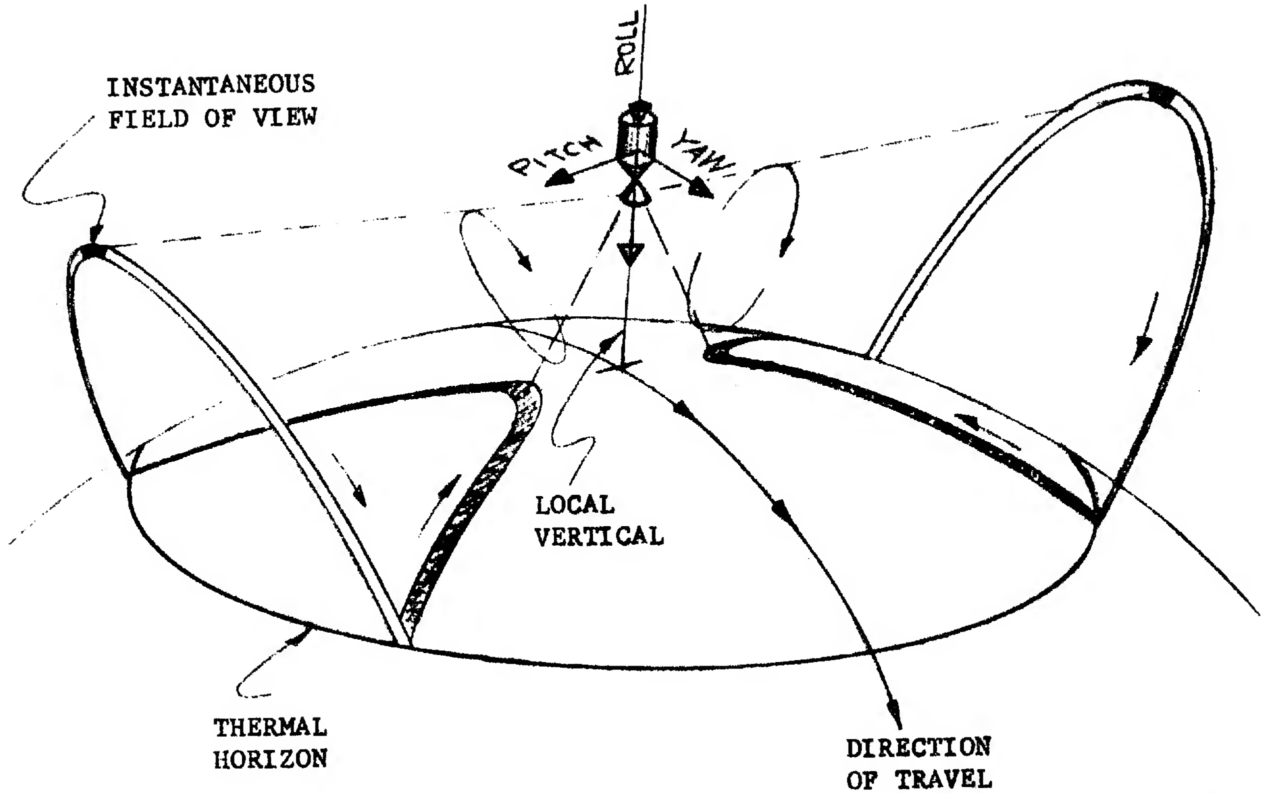
4.1.7.2 Recommended Configuration - The existing G&N system in the CSM is recommended as the prime method for local vertical control. The G&N system meets the pointing and rate requirements with the following capabilities:

1.0 deg. + 0.15 deg/hr drift (includes initial alignment and limit cycle)

.03 deg/sec limit cycle rate.

The only modifications to the CSM required are that the appropriate routines must be included in the G&N computer programming.

A backup system is also recommended for local vertical control to assure that the important earth resources experiments will be successfully oriented. The preferred system is a carrier mounted horizon-scanner-gyrocompass reference system driving a display for manual control by the astronaut. Figure 4.1.7-1 illustrates the backup system. Activities are continuing at Martin Marietta to assess the performance of this system, including accuracy and RCS fuel consumption. The system has the advantage of considerably less power usage



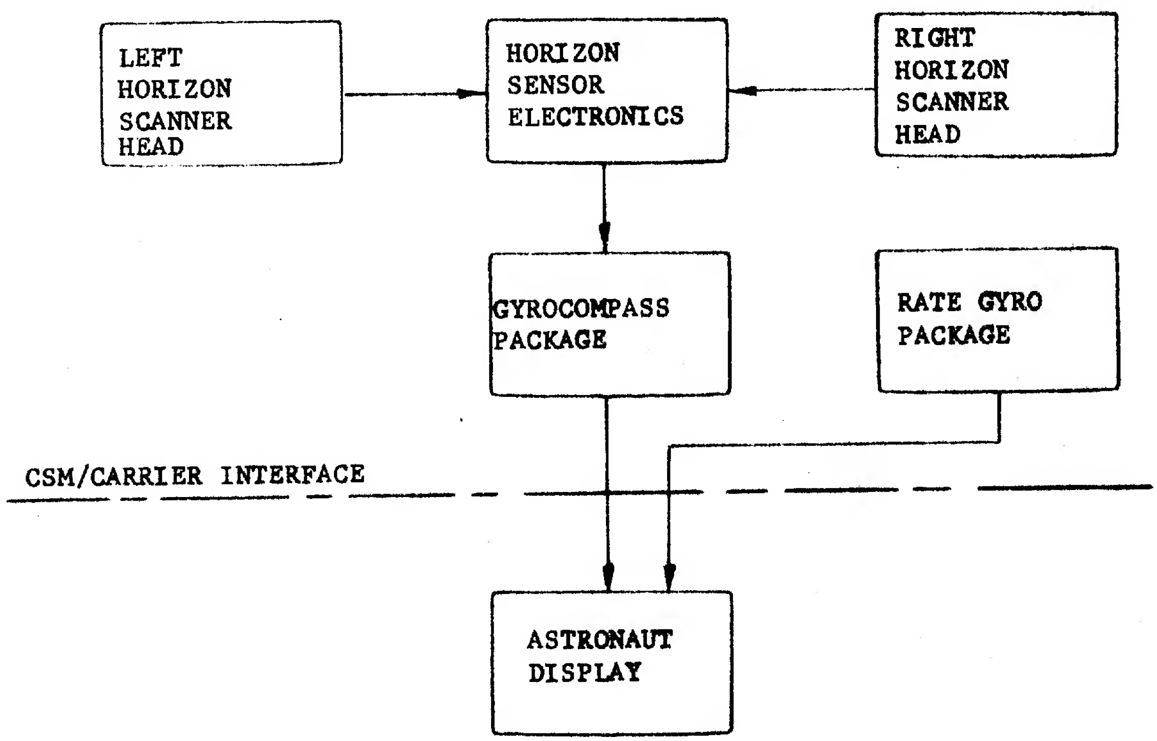


FIGURE 4.1.7-1 BACKUP LOCAL VERTICAL CONTROL SYSTEM

4.1.7.2 (Continued)

than the G&N system (50 watts compared to 500 watts). Some of the disadvantages are the need for additional wires across the docking interface and the involvement of the crew to control the vehicle. An investigation is also continuing at Martin Marietta to evaluate a horizon scanner-gyrocompass system with control logic electronic that would interface with the RCS thruster to automatically control the vehicle.

The recommended technique for control to the sun line is manual control by the crew using a display in the CSM. Input signals to the display would be furnished by sun sensors mounted in the experiment carrier.

Stellar orientation would be accomplished by a coarse acquisition with the CSM G&N system and fine pointing by manual control. Experiment S017 would provide an error signal for display and the G&N system optical scanning telescope (SCT) would be used for S019.

Table 4.1.7-II gives the estimated propellant budget by experiment. The table is based on the recommended configuration and the mission plan developed in PR 29-46, Mission Timelines. The table does not include a reserve for contingencies such as venting disturbances or a one quad out failure condition. Provision for such contingencies would require a reduction in the experiment schedule.

Propellant required for maneuvers and attitude hold is given in Vol. 3 of SID 66-1501-A, Mission Modular Data Book (MMDB), revised 15 March 1967. A conservative value for maneuver propellant results if a simultaneous three-axis 50 deg. SCS manual maneuver is assumed. Curves in the MMDB give a 0.98 lb. propellant requirement for this assumption and a 34,000 lb. vehicle which approximates the Mission 1A configuration. As a check, propellant was calculated on the assumption of a sequential three-axis maneuver with approximately 30 percent system overshoot and no cross coupling.

TABLE 4.1.7-11 ESTIMATED RCS PROPELLANT BUDGET

EXPERIMENT	RCS PROPELLANT
T002, Manual Navigation Sightings	20 lbs
D009 Simple Navigation	36
S016 Trapped Particle Asymmetry	76
S017 X-Ray Astronomy	45
S019 UV Stellar Astronomy	33
S020 XUV Solar Photograph	16
Standard Applications	44
Sub-Total	270
Rate Damping during drift periods	11
Total	281 lbs

4.1.7.2 (Continued)

The calculation result was 0.96 pounds which is in agreement with the MMDB and was rounded off to 1.0 lb/maneuver for use in Table 4.1.7-II.

Propellant required for attitude hold is dependent on the control mode, orbital altitude and vehicle orientation. The MMDB curves result in a value of 0.5 lb/hr for fine deadband (0.5 deg) G&N mode attitude hold. To achieve this performance would require some optimization of the limit cycle characteristics in the presence of disturbance torques but as the CMC has this capability the 0.5 lb/hr value was accepted as realistic.

Propellant consumption for manual attitude hold can best be determined by a simulation study. An applicable study was performed for experiments S019 and S020, the results are given in MSC Note No. 67-EG-13, Results of a CSM Attitude Control Task Simulation for Experiments S-19 and S-20, 3 April 1967. The results show propellant consumption of approximately 3 lb/hr to maintain an attitude hold with a maximum deviation of 0.25 deg from the experiment reference. This may be compared to an SCS automatic fine mode hold shown by the MMDB to require 2.9 lb/hr. These values are significantly higher than could be achieved with more nearly optimum control. In Table 4.1.7-II this is considered to result in a conservative estimate as attitude hold accuracy of 0.25 deg is not required throughout all manual control periods.

The estimated electrical energy required for pointing and stabilization is 47 KWH to be furnished by the CSM Electrical Power System. A contingent requirement of 4 KWH is imposed on the experiment carrier electrical power system for the local vertical backup system.

The estimated weight of the local vertical backup system to be added to the experiment carrier is 46 lb.

4.1.7.3 Trade Study Summary - Details of the attitude control and pointing trade studies are contained in PR 29-43, "Pointing and Stability Studies". The results of these studies are summarized in this section.

4.1.7.3.1 Local Vertical Orientation - A substantial portion of the AAP-1A mission is to be flown with experiment sensors oriented toward the nadir that is, with the instrument sensitive axis viewing the ground track of the orbital vehicle.

A general approach was taken at the inception of the study and consisted of an evaluation of a wide range of reasonable control approaches to maintain the desired attitude. The range considered progressed from passive stabilization to manual control, use of present CSM systems and through increasingly complex supplementary systems. Specifically the following approaches were considered:

- Passive gravity gradient stabilization with manual RCS damping.
- Manual with astronaut optical aides.
- Automatic with Stabilization and Control System (SCS).
- Automatic with Guidance and Navigation (G&N) System.
- Carrier mounted Local Vertical System (LVS) correcting SCS gyros.
- Carrier mounted LVS direct to RCS solenoids.
- Carrier mounted LVS with independent propulsion.
- Combination of the above.

A preliminary study was conducted with principal emphasis on factors of cost, CSM modifications, RCS propellant usage, power and weight. The preliminary trade study results indicated the principal candidates to be the existing G&N system and a carrier mounted local vertical system driving the RCS thrusters. An analysis of relative orbital disturbance torques resulted in the elimination

4.1.7.3.1 (Continued)

of passive gravity gradient stabilization as a candidate system due to the magnitude of aerodynamic torques. Other alternatives were eliminated largely because of cost, CSM modification and RCS propellant usage.

4.1.7.3.2 G&N System Local Vertical Mechanization - Local vertical orientation with the G&N system may be provided by incorporating the appropriate routines in the CMC. In operation, the computer would combine the known orbital ephemeris with inertial coordinate data from the IMU to calculate the direction of the local vertical vector and align the vehicle to properly point the experiments. Additional constraints are imposed on the CMC program by the experiment angular offsets from the CSM Navigation Base on which the IMU is mounted and the limited angular freedom of the IMU middle gimbal.

Differences in angular alignment between the Navigation Base (NB) and experiments are a potential source of substantial pointing error since the CSM coordinate system is referenced to the NB. Errors accumulate from the NB to the CSM docking adapter, across the docking interface to the experiment carrier, and through the carrier structure to the experiments. The largest error would lie between the NB and the carrier structure. The following deviations might be expected after docking:

Azimuth: 10 deg. max
Pitch or Yaw: 5 deg. max.

It is necessary, therefore, that the misalignment between the experiments and the NB be measured after docking and that the CMC program accept these measured values as keyboard data inputs. The CMC local vertical routine must incorporate the capability to correspondingly offset the orientation of the NB defined coordinates to compensate for experiment misalignment.

Several methods of determining experiment relative alignment have been considered. The recommended method utilizes a two axis optical sighting device located in the carrier and attached to a surface machined to constrain the base of the sighting device in three axes. The angular relationships between the sighting device

4.1.7.3.2 (Continued)

base and the experiment mounting bases are measured and established at installation. Using this device, an astronaut can acquire a selected reference star. By sighting the same star with the G&N telescope and reading the gimbal angles simultaneously, a reference between the two optical systems is established. Repetition of this procedure with a second star would complete the necessary data acquisition to establish the experiment alignments relative to the NB.

The second constraint on operation of the G&N system in a local vertical mode is the limited angular freedom of the IMU middle gimbal. The CSM G&N system utilizes a three gimbal platform and the possibility exists of approaching gimbal lock conditions during vehicle pitch maneuvers. Should this region be approached, very high gimbal acceleration torques may be called for by the gyro in order that the stable element be held fixed in inertial space. If these acceleration torques are not available, the stabilization loops may saturate causing a platform "dump". This will cause a loss of the attitude reference previously held by this device.

To evaluate local vertical operation a model of the system was developed for digital simulation. The results of the simulation show that constant pitch rates following initial yaw displacements of greater than 10 degrees can yield a potential problem by approaching gimbal lock conditions and consequent high gimbal rate requirements. Conditions other than these produce either constant or periodic gimbal rates that do not greatly exceed the body rate driving function. Therefore, the CMC IMU alignment routine must provide that the vehicle null yaw orientations lie in or near the orbit place. Also, maneuvers about the vehicle yaw axis must be restricted during local vertical periods.

Over half of the experiments require controlled orientation and over half of the attitude controlled operating time of the mission requires local vertical control. The importance to the mission of local vertical control, as well as the reliability uncertainty of the G&N system for the planned operating time, requires that a backup system be recommended.

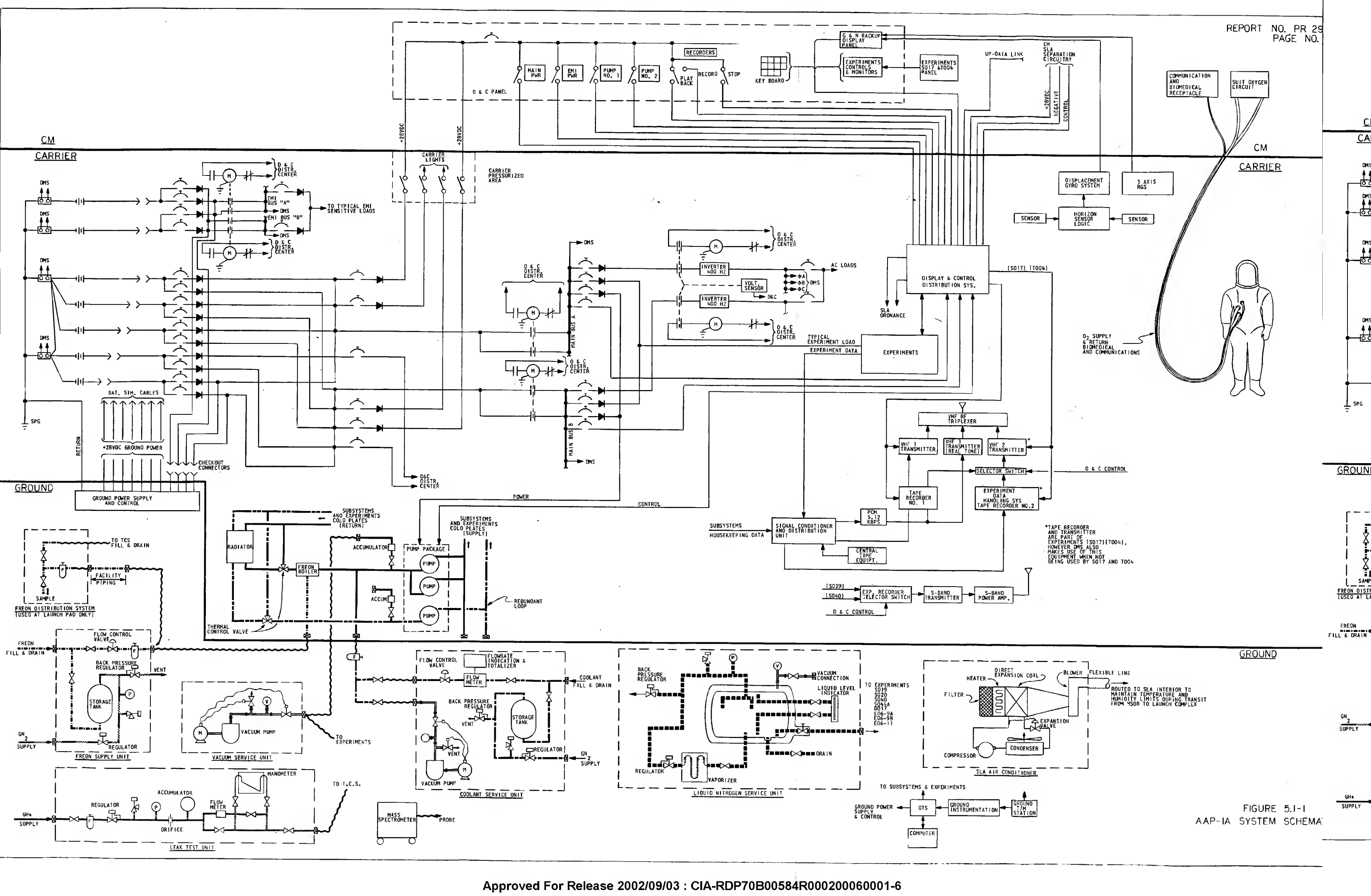


FIGURE 5.1-1
AAP-IA SYSTEM SCHEMA

4.1.7.3.2 (Continued)

A number of backup local vertical systems were considered. All are based on man-in-the-loop operation and would provide a display to the astronaut from which the astronaut would command vehicle attitude using the hand controller. The systems which were evaluated are:

- Optical local vertical control using an instrument which would image sectors of the horizon and operate in conjunction with a drift meter device.
- Use of G&N optical system to provide periodic local re-alignment with SCS control.
- Horizon scanner and gyrocompass mechanization driving astronaut display for manual control.

The last of these is the recommended alternative on the basis of efficient RCS propellant utilization.

The system electrical outputs may be displayed in conjunction with vehicle angular rate data. The combination of attitude and rate on an appropriate display, combined with crew training, would make it possible to approach optimum limit cycle operation with a resultant significant decrease in RCS propellant usage rates as compared to the other alternatives.

4.1.7.3.3 Carrier Mounted Local Vertical System - The second principal candidate for primary local vertical control is a carrier mounted local vertical system. It would be comprised of a three axis reference system and control logic mounted in the carrier and would interface with the SCS at the output of the RCS drivers. A horizon scanner - strapdown gyrocompass combination is expected to provide a sufficiently accurate three axis reference. The system would save approximately 25 KWH of CSM fuel cell energy when compared to G&N system operation at the cost of a 5 KWH carrier battery requirement. The system would also allow more margin for use of the G&N system and computer for other experiments. The necessary horizons sensors and gyros are available and flight qualified. Electronics development would be required.

4.1.7.3.3 (Continued)

Control in pitch and yaw is straightforward with a horizon sensor system. Control of azimuth is more complex. Various methods of azimuth sensing are described in the literature; they include in the approximate order of decreasing accuracy:

(1) Stable gimballed platform
(2) Stable analytic platform
(3) Body mounted two-degree-of-greedom gyro.
(4) Body mounted single-degree-of-freedom gyro(s).

Selection of a specific method for AAP 1A is influenced to a large extent by the following factors.

- Simplicity of design and minimal computational requirement.
- Availability of flight proven hardware.

In this context: method (1) is not considered because of its unavailability as flight proven hardware; method (2) is not desired because of either the complexity of its analog realization or the computational requirements for its digital implementation.

The choice of methods (3) and (4) is the subject of continuing investigations; method (4) concerns primarily the possibility of treating the complete vehicle as a stabilized platform. Certain operating conditions appear favorable to that concept, i.e.:

- Vehicle principal axes of inertia are advantageously oriented with respect to gravity gradient
- Orbit is nominally circular
- Deviation and rates of deviation (limit cycle rates) from nominal reference orientation are small.

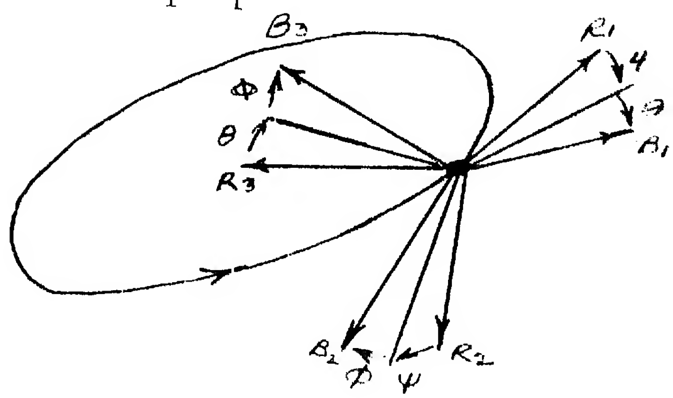
4.1.7.3.3 (Continued)

Problems under consideration include the following areas:

- Effective orientation of gyro(s)
- Influence of sensor noise on accuracy of heading information
- Influence of sensor dynamics on stability
- Effects of environmental disturbances
- Selection of a compatible control system.

To illustrate the concept of treating the vehicle as a stabilized platform, the following simplified equations are developed:

- The following sketch illustrates the orientation of the orbit reference coordinate system R and the body reference system B. Frame B differs from Frame R by the small euler angles $\Delta\phi, \Delta\theta, \Delta\psi$. The sequence of rotation from R into B is ψ about R_3, θ about displaced R_2 ($=R_2'$); ϕ about twice displaced R_1 ($=R_1'' = B_1$).



R_1 in direction of velocity

R_2 normal to orbit plane

R_3 towards center of earth

4.1.7.3.3 (Continued)

With the appropriate transformation the following are equivalent rate expressions in the coordinates of B:

[illegible]

As a first approximation, it is assumed that the B_1 and B_3 terms are represented with sufficient accuracy by:

[illegible]

It follows that with the proper biasing of integrating gyros mounted on these axes, secondary roll and yaw information is obtained.

The systems shown in Figures 4.1.7-2 and 4.1.7-3 are being examined in continuing simulations and analysis as possible candidates for a strap down gyrocompassing scheme, i.e., strap down without electronic gimballing.

Basically the two systems are quite similar that is, the purpose of the feedback paths containing gains K_3 and K_4 (second order system) and K_5 and K_6 (third order system) is to reduce the cross coupling inputs seen by the roll and yaw gyro respectively. In both systems the error signal developed by taking the difference between the horizon scanner output and the roll gyro feedback is used to torque the yaw gyro - the purpose is to decrease the response time of the gyro compass loop. The difference between the two systems shown is in the path of this error signal to the yaw torque generator, i.e., the third order system divides the signal in this path and provides an integration in one of the paths. The respective transfer function and steady state errors of the two systems as a function of gain are shown in Table 4.1.7-III.

4.1.7.3.4 Solar Orientation - One experiment proposed for AAP Flight 1A, S020, requires orientation toward the sun. Two approaches for vehicle control during the operation of this experiment were considered: Use of the experiment display and control of the vehicle from a remote display.

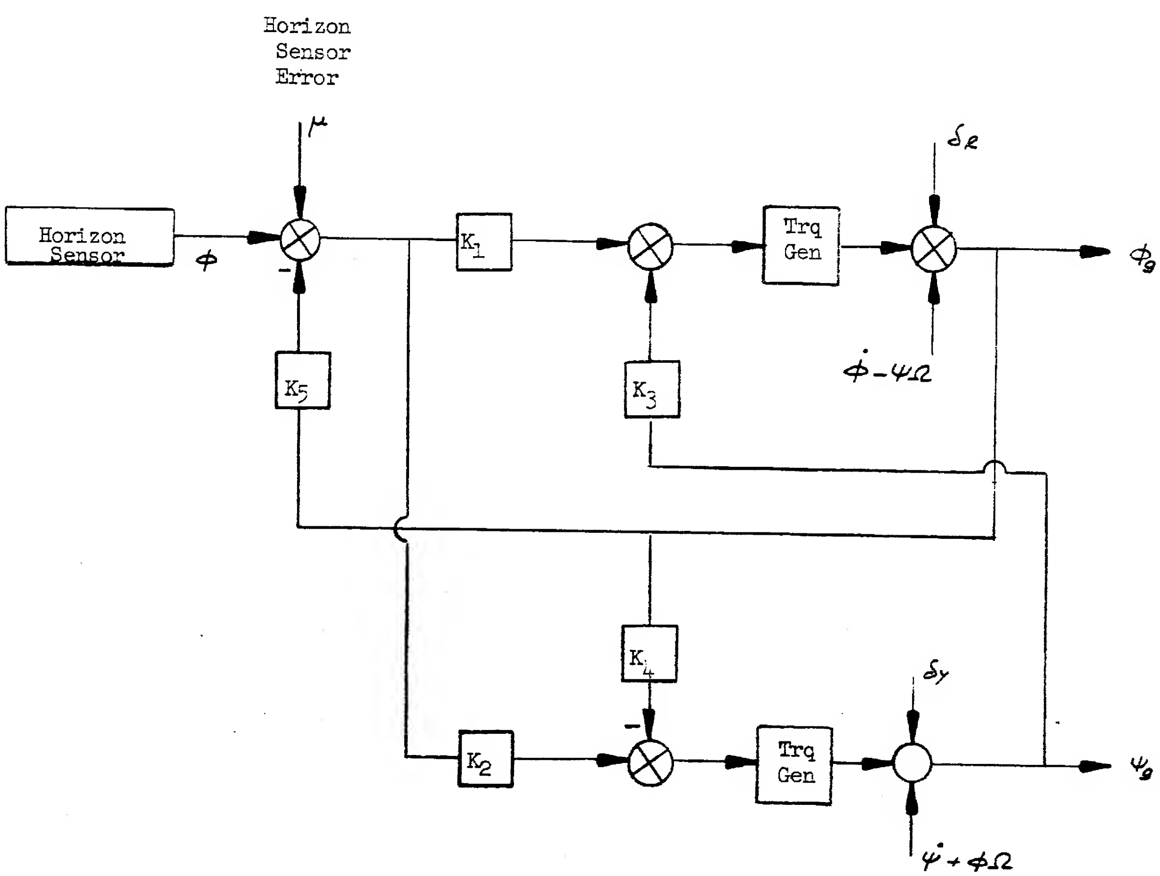


FIGURE 4.1.7-2 STRAP-DOWN ORBITAL GYRO COMPASS, SECOND ORDER

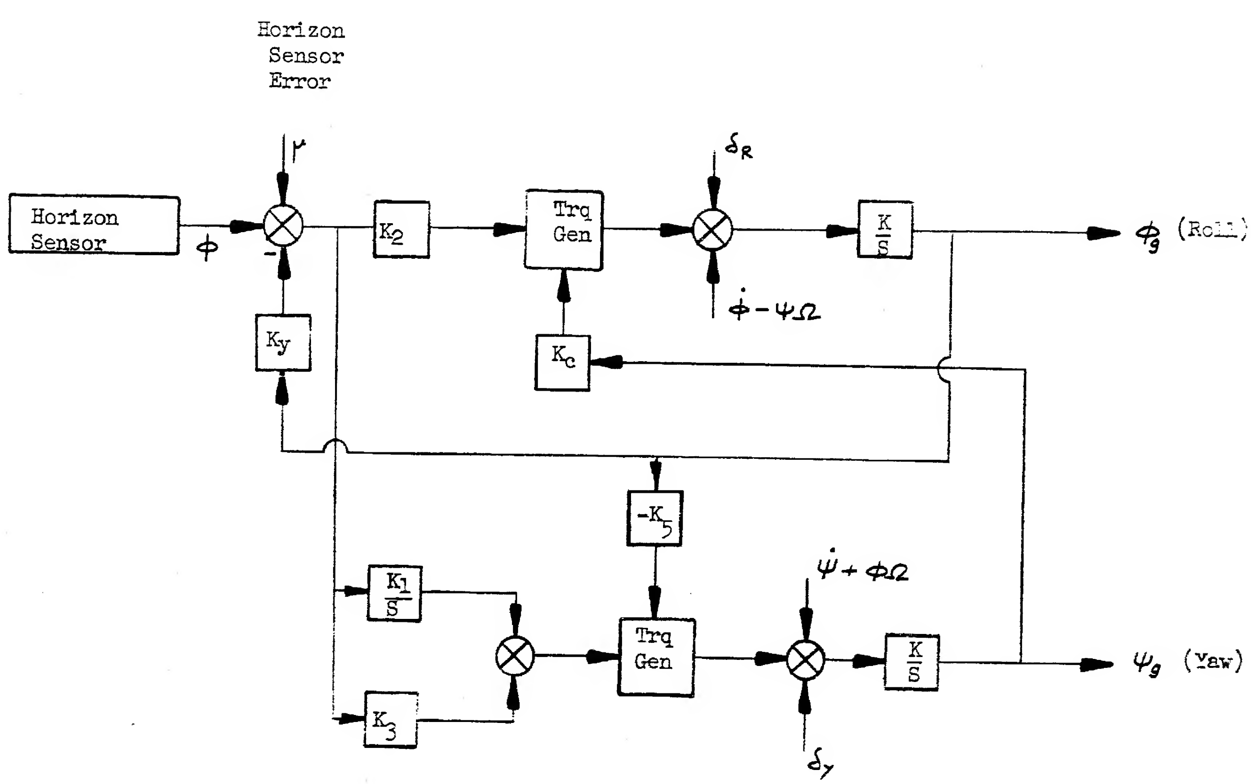


FIGURE 4.1.7-3 STRAP-DOWN ORBITAL GYROCOMPASS, THIRD ORDER

STEADY STATE ERRORS

	2nd ORDER	2nd ORDER SYSTEM	3rd ORDER SYSTE
HORIZON SCANNER BIAS	$\frac{\psi_s}{\mu} = \frac{KK_2(S-KK_1K4/}{S^2+KK_1K_5S+K^2}$	$\frac{-K_1K_4}{K_3(K_2K_5+K_4)}$	0.
YAW GYRO DRIFT	$\frac{\psi_s}{\delta_y} = \frac{K(S+KK_1K_5)}{S^2+KK_1K_5S+K^2}$	$\frac{K_1K_5}{K_3(K_2K_5+K_4)}$	0.
ROLL GYRO DRIFT	$\frac{\psi_s}{\delta_R} = \frac{-K^2(K_2K_5+K_4}{S^2+KK_1K_5S+}$	$-\frac{1}{K_3}$	$-\frac{1}{K_6}$
ROLL ANGLE	$\frac{\psi_s}{\phi} = \frac{[K(K_2+\Omega \quad]}{S^2+KK_1K}$	$\frac{K_1(\Omega K_5-K_4)}{K_3(K_2K_5+K_4)}$	0.
YAW ANGLE	$\frac{\psi_s}{\psi} = \frac{K[S^2+KK_1K_5}{S^2+KK_1K_5}$	$+\frac{\Omega}{K_3}$	$-\frac{\Omega}{K_6}$

4.1.7.3.4 (Continued)

Manual control using the experiment display is a simple and accurate method from the control system standpoint. The only modification required would be to provide a longer cable with one hand controller so that the unit could be carried into the experiment carrier. However, objections arise both to a control station in the experiment carrier and to a cable through the docking tunnel and across the CSM/Carrier interface.

A sun sensor system offers the capability of control from the CSM. The sensor's output would be routed to the experiment Display and Control Console in the CSM to drive an appropriate two axis display.

4.1.7.3.5 Stellar Orientation - Two experiments, S017 and S019, require orientation to stellar targets. Current mission planning provides that the vehicle will be maneuvered with the G&N system to point the experiments at a region of interest. Fine pointing and attitude hold will then be provided by an astronaut using the hand controller. As with S020, one of the hand controllers could be taken forward to the experiment carrier but the same objections would again be applicable.

The display for experiment S017 consists of a set of lights and, since the input to the display consists of electrical signals, is compatible with remote mounting for use at a control station in the CSM. Experiment S019, however, provides a telescope for the astronaut pointing reference. Manual control from a station in the CSM for this experiment will require use of the SCT which must be aligned to the experiment LOS and can then be used as the pointing reference for astronaut manual control.

5. SYSTEMS INTEGRATION -

5.1 Systems Engineering -

Systems Engineering techniques were used to ensure the carrier and subsystems design met the program objectives as stated in Paragraph 1.1. Through the use of a systems engineering approach for analyzing and integrating engineering requirements, these program objectives were accomplished. The primary systems engineering activities included the following tasks:

- Preparation and maintenance of a criteria and requirements document - The Mission 1A Program Technical Requirements and Criteria document was created to provide a single centralized source of design information. This design information included the program objectives, design constraints, and a complete synopsis of reliability, crew safety, maintainability, human factors, subsystem and experiment requirements including a description of the design approach for each subsystem. This information, updated on a weekly basis, provided each design area with current knowledge on the overall aspects and progress of the carrier design.

- Analysis of functions to be performed - Each experiment and subsystem function was analyzed for compatibility with the requirements document and for the impact on subsystem design and the CSM. Changes to functions were made if the cost was prohibitive, weight aspects excessive, crew safety compromised, or if an alternate method would eliminate modifications to the CSM.

- Evaluation and concurrence of subsystem design approaches - Prior to the incorporation in the requirements document, the basic subsystem design descriptions and all subsequent design changes were evaluated.

- Coordination of experiment and subsystem operational requirements - Operational requirements and physical descriptions of each experiment or subsystem were analyzed to determine the effect on the overall carrier design. Preliminary power and weight studies were performed to determine compliance with mission duration and total weight limitations.

- Investigation of CSM interfaces and capabilities with respect to carrier support - Meetings with NAA were attended to determine configuration of the Block II CSM in terms of existing LM interfaces and CSM capabilities for furnishing power, oxygen pressurization, display and control mounting area, and data handling requirements in support of the experiments and carrier subsystems. Data and drawings were disseminated to the cognizant subsystem design groups.

- Preparation of a system schematic - In conjunction with the requirements document which provides a verbal description of the carrier, a visual presentation of the carrier electrical and fluid subsystems was provided in the form of a system schematic (Figure 5.1-1) which depicts the interactions between the various subsystems.

- Meteoroid vulnerability analysis - PR29-23, Meteoroid Vulnerability Analysis presents an analysis of the carrier pressure shell and radiators using a NASA-MSC model of the meteoroid environment and Summer's penetration equation. The calculations show the need for additional protection for the pressure shell. This can be achieved with the addition of a 16 mil thick aluminum bumper between the two subsystems racks and an increase of 10 mils in the dome thickness. The calculations also show that adequate protection has been provided for the radiators.

5.2 Safety

5.2.1 Summary - A preliminary analysis of the crew/systems safety aspects for AAP-1A and its overall safety requirements and considerations have been accomplished. Safety program objectives have been established to assure that the carrier/experiment design and the prelaunch and flight mission operation shall not create unnecessary hazards for the crew and launch area personnel or to the equipment and facilities. These objectives will be achieved by establishing a strong program awareness of the crew involvement thru specific safety design standards and criteria, participation of system safety personnel in design reviews to assure compliance with this criteria and performing systems and operational hazard analysis. A further discussion of the safety program is contained in Trade Study PR29-41, Final Systems Safety Report.

5.2.1.1 Systems and Crew Safety - Systems Safety functions are directed toward the elimination or minimization of hazards in the carrier system, and Crew Safety is concerned with analyses and hazard identification relative to crew equipment, astronaut functions and operations that could effect crew safety. Crew/Systems Safety Criteria for the AAP-1A Experiment Carrier include requirements for fire detection, pressure relief and monitoring, illumination, thermal monitoring and control, communication, tethers, restraints and mobility aids, meteoroid penetration, and radiation. These requirements are discussed in Paragraph 3.3.2 of this report.

5.2.1.2 Range and Pad Safety - Hazards attendent to the space vehicle operations including the ground handling gear and the prelaunch operations are included in this area. Range Safety requirements specified in Air Force Eastern Test Range document AFETR 127-1 will be complied with. The design of the experiment carrier, however, is not expected to impact range safety considerations of the Saturn 1B launch vehicle. No changes should be required to such range and pad safety documents as the Occupational-Medical Hazards Report, the Pad Safety Plan and TNT equivalency considerations.

No high pressure vessels or spheres are intended to be included in the carrier design and the only pyrotechnics involved are the SLA/Carrier separation devices which will be the same LM hardware used on previous LM flights. There will be no propellants involved in the Carrier design.

5.2.1.3 Industrial Safety - An Industrial Safety program will be carried on during the build, test and launch phase of the 1A Mission. This program will comply with the Walsh Healy Act and applicable company and NASA management policies.

5.2.2 AAP-1A Safety Evaluation -

5.2.2.1 Carrier Design Features - The manned portion of the baseline experiment carrier as presently conceived for AAP-1A contains a conical pressure chamber assembly with a free volume of approximately 190 cubic feet. After docking with the CM, the carrier hull will be pressurized to 5.0 psia using the CSM oxygen supply. It is anticipated that the major portion of the flight mission will be accomplished with the CM pressure-thermal hatch closed. Occasional IVA entry by a single crewman will be required to retrieve data or to operate experiments. Carrier

airlocks will be qualified CM units available from the Block I Apollo program. Only equipment which requires crew manipulation has been located within the carrier pressure vessel. All other items are mounted externally on the external truss structure. The carrier pressure vessel inner surfaces will be free from protuberances and sharp edges.

Systems safety consideration are also involved with the design of these external subsystems. Ground servicing functions and component and experiment handling and installations within the SLA pose a potential hazard to the ground crew and the launch vehicle. Positive means will be provided to restrain and control items handled within the SLA to prevent possible damage to the SIVB tank dome or other structure or components. Proposed handling techniques are covered in the Trade Study PR29-34, Maintainability. Safety design features of the carrier include the following:

5.2.2.1.1 Fire Detection - A study will be made to determine the need for a remote fire detection system with read-out indications on the D&C panel. Operating constraints may include a requirement to power down experiments prior to crew entry into the carrier with this safe condition confirmed on the D&C.

5.2.2.1.2 Pressure Relief and Monitoring - A means will be provided to assure pressure equalization across the CM pressure-thermal hatch prior to hatch opening. The carrier will also be provided with a remotely operated vent valve to bleed the pressure hull to vacuum prior to initiation of the CM/carrier pyro separation system. The Block II CM/LEM 4-way pressurization valve and CM hatch equalization valve and a pressure differential monitoring gauge is the baseline.

5.2.2.1.3 Illumination - Overall illumination will be specified at 20-30 foot candles intensity in the carrier. Local lighting may be necessary for performing work behind barriers or in confined areas. The need for portable emergency illumination equipment will be studied. All lighting equipment will be safe for use in a 5 psia O_2 atmosphere.

5.2.2.1.4 Temperature and Thermal Control - Carrier design will include provisions to determine and monitor atmosphere temperature in the carrier. Forced air circulation in the carrier will be studied for shirt sleeve flight mode. The carrier active thermal control system is a cold plate and radiator system using Freon 21 as the fluid. Crew risk from fluid leakage is eliminated by designing the entire liquid loop system external to the carrier pressure hull.

5.2.2.1.5 Communications - Communications between crew members during periods of carrier habitation are essential for safety. The present hard wire system will probably be used; however, the need for voice or enunciator back-up will be studied.

5.2.2.1.6 Tethers, Restraints and Mobility Aids - Carrier IVA was baselined for the study with crew members suited in the ILC-A7L suit and the carrier crewman's CM umbilical providing oxygen and the bioinstrumentation/communication link. The soft suited crew baseline was established to be consistent with Block I scientific airlock operations in the CM. Shirt sleeve entry will also be explored and the hazards of this operational mode assessed. A tether harness for the suited crewman will be used at all crew task locations in the carrier. Hand rails and/or other mobility aids will be employed to assure safe crewman translation. Restraining devices will also be used to provide controlled transport of retrievable experiment data (cassettes, etc.) between the carrier and the CM. The carrier/experiment systems will be shut down and/or in a safe condition prior to crew entry. This condition will be verified on the Display and Control panel in the CM.

5.2.2.1.7 Meteoroid Penetration - Meteoroid penetration of the carrier pressure vessel will be minimized by material wall thickness selection and strategically located barriers on unprotected segments of the conical shell. This analysis is covered in Trade Study PR29-23, Meteoroid Vulnerability Analysis.

5.2.2.1.8 Radiation - The AAP-1A mission involves an earth orbit of 120/140 nm at an inclination of 50°. Preliminary studies indicate that human shielding will not be required. No EVA is planned for the mission. Possible shielding requirements for experiments and film are being studied.

5.2.2.2 Experiment Impact - Carrier experiments will continue to be assessed for any hazard contributions to the total system. Each experiment will be analyzed to ascertain freedom from hazard to crew or mission either in a normal operating mode or as a result of failure. Assurance from GFP sources or additional testing may be required to assure that experiments comply with fire, out-gassing and odor criteria.

5.2.2.3 Mission and Crew Considerations - The current AAP-1A mission span is open ended to 14 days. Safety reviews and inputs to the mission time lines and crew evaluation studies will continue. This will include the review, analysis and approval of forthcoming design specifications, operating procedures, and the life support systems, equipment and working quarters involved with the carrier.

5.2.3 Non Metallic Material Compatibility - Non-metallic material selection as a function of carrier design is recognized as a potential problem and controls will be exercised through a board to assure crew safety and mission success. Non-metallic materials for the AAP-1A mission will be selected in general accordance with ASPO-RQTD-D67-5A "Non-metallic Materials Selection Guidelines" and MSC-A-D-66-3 Revision A "Procedures and Requirements for the Evaluations of Spacecraft Non-Metallic Materials". It will be a design goal to select materials that have demonstrated test compliance with MSC-AD-66-3. Apollo and Gemini program components and/or assemblies will be used whenever possible. Close communication will be maintained with the Non-metallic Materials Information Center at MSC. The non-metallic flammability test data provided in the Characteristics of Non-metallic Materials (COMAT) listing prepared by this information center will be used as one of the bases of material selection. Additionally, data relative to Apollo Command Module components that have been requalified or on which waivers have been obtained, will be reviewed. A Non-metallic Material Selection Review Board will be established at Martin to review candidate materials. This board will be chaired by Materials Engineering and will have a representative from Crew/Systems Safety, Reliability and Test. Requests for deviation from the selection criteria will be processed through this board and submitted to the designated NASA-MSC board for approval. GFP items, including experiments, are considered to be provided by the Government as qualified system elements verified to conform to the non-metallic material selection criteria.

The Contractor is responsible to analyze the experiments and their installation placement and inter-relationships to assure that system hazards and mission degradation cannot result from experiment inter-reaction. Refer to Trade Study Report PR29-9, Non-Metallic Material Selection Criteria and Guidelines AAP/PIP Early Applications, for further information on this subject.

5.2.4 Safety Program Implementation Plans - A Systems Safety Engineering Plan will be developed to set forth the contractor's safety organizational network, methods of approach, and areas of technical concentration. This plan will be developed in general accordance with the proposed Apollo Applications Safety Program Plan and Safety Engineering Specification MIL-S-38130B. It is intended that the plan will present a reasonable program, the dimensions of which maintain a rational relationship with the magnitude, complexity and risks of the proposed program. The recommended program will contain hazard analysis techniques. There will be a close tie with failure mode effect and criticality analysis (FMECA) covered in Paragraph 5.3, Reliability, and a strong working relationship with the assigned mission crew to assure a high level of program safety awareness during design, build, test and flight operation.

5.3 Reliability -

5.3.1 Reliability Approach - The primary objectives of the reliability program during the study phase were to evaluate and support design concepts that would promote a successful AAP-1A mission and to develop plans for a reliability program compatible with further development of the AAP-1A mission carrier. Successful reliability aspects of the Gemini Flight and Crew Safety methods have supplied valuable data to assure success of the mission. The approach taken to ensure a reliable design of the carrier and its subsystems included the following tasks:

- Initial apportionment of reliability goals among carrier subsystems to reflect the configuration of the carrier at program start.
- Preliminary prediction of reliability to measure degree of compliance with apportionment.
- Final prediction under a worst-case condition using the most stringent anticipated mission profile.

- Final apportionment to serve as a basis for numerical reliability requirements for all subsystems, including the guidance and navigation back-up subsystem.

Periodic design reviews will be scheduled in the next program phase to provide a comprehensive audit of carrier design. Design review activity will encompass the carrier, its subsystems, GSE, and experiments to identify critical problem areas, and to determine the capability of the system to meet performance and interface criteria. Specific attention will be given to single-point failures as identified by Failure Modes, Effects and Criticality Analysis (FMECA) that compromise crew safety or primary mission objectives, and the results of development and qualification test programs.

5.3.2 Reliability Analysis - The reliability goal/allocation to meet program requirements for a 14-day mission is 0.9700. This reliability value was selected because the carrier and subsystems for AAP-1A are of comparable complexity to the carrier and subsystems for Apps A & B which had previously been evaluated. Apportionments for each carrier subsystem are contained in Table 5.3-I.

Table 5.3-I

Reliability Predictions and Apportionments

Subsystems	Apportioned Reliability	Predicted Reliability
Structure	0.9995	0.9999
Power	0.9980	0.9983
Thermal Control	0.9990	0.9993
Data	0.9765	0.9776
Display and Control	0.9995	0.9995
Guidance & Navigation	0.9975	0.9975
TOTAL	0.9700	0.9722

These predictions are based on a worst-case condition with ground rules and assumptions listed in Study Report PR29-35, Preliminary Reliability Prediction. Among the more significant assumptions and ground rules are the following:

- The carrier contains 7 batteries which in turn provide power for 13 experiments. The excess capacity in the power subsystem is 19.6 KWH.

- One PCM encoder failure and one signal conditioner failure are permitted in the data subsystem with the provision that each failure will affect no more than one data channel. The precedent for this approach has been established in the specification for the Apollo encoder in which NASA requires a mission success probability of 0.9997 for 200 hours with the loss of no more than five analog and eight digital channels.

- The "ratio of-Q" method was used to arrive at a final apportionment for carrier subsystems. This model allocates 78% of permissible system unreliability to the data subsystem.

5.3.3 Reliability Plan - Three elements selected from NHB 5300.5, Apollo Applications Reliability and Quality Assurance Program Plan, represent the focal points for the AAP-1A mission reliability program. They are an FMECA on each experiment and support subsystem with feedback to the design agency, a comprehensive test program, and positive reaction to each failure encountered in test. The Test Program will aid in substantiating the failure modes identified in the FMECA and will supply additional data points for design resolution. If the failure mode is confirmed, corrective action is mandatory and is subject to review and approval. With this approach, equipment designed for AAP-1A will be brought to maturity at the earliest possible time.

The interdependence of experiments and support subsystems necessitates a program requirement to prevent the effect of a failure from propagating across equipment interfaces. Therefore, constraints will be imposed on equipment design to prevent such occurrences. Pre-planned options will be developed for failure contingency affecting crew safety or primary mission objectives. The scope of reliability requirements imposed upon each article of equipment in the carrier will be determined by the criticality of that equipment to crew safety and 1A mission objectives. The categories of equipment criticality are defined in Table 5.3 - II.

Table 5.3 - II, Component Criticality Category*

1. Flight Hardware

a.	Category 1 Failure	The failure of any flight hardware which could adversely affect crew safety.
b.	Category 2 Failure	The failure of any flight hardware which could result in not achieving a primary mission objective but does not adversely affect crew safety.
c.	Category 3A Failure	The failure of any flight hardware which could result in not achieving a secondary mission objective but which does not adversely affect crew safety or preclude the achievement of any primary mission objective.
d.	Category 3B Failure	The failure of any flight hardware which could not result in loss of primary or secondary mission objectives nor adversely affect crew safety.

2. Ground Support Equipment

a.	Category A Failure	The failure of any ground support equipment which could cause loss of a vehicle/module or adversely affect crew safety.
b.	Category B Failure	The failure of any ground support equipment which could result in not achieving primary mission objectives or cause a launch scrub.
c.	Category C Failure	The failure of any ground support equipment which could result in not achieving secondary mission objectives or cause a launch delay.
d.	Category D Failure	The failure of any ground support equipment which does not fall into the above three categories.

*Ref. NHB5300.5 Apollo Applications Reliability and Quality Assurance Program Plan

Approved For Release 2002/09/03 : CIA-RDP70B00584R000200060001-6

5.4 Logistics, Accessibility and Maintainability -

5.4.1 Summary - The closely related areas of Logistics, Accessibility, and Maintainability were analyzed to ensure that the 1A Mission hardware and eventual procedures would reflect a realistic approach to total system support. These analyses are documented as trade study reports: PR-29-4, On-Pad Accessibility; PR-29-18, Logistics Support Criteria; and PR-29-34, Maintainability Analysis.

5.4.2 Logistics Support Approach - Logistics Support will be required for the AAP-1A Mission at three locations: at Denver to support initial installation, integration and checkout of the integrated experiments and carrier assembly; at MSC and KSC to support operation and maintenance of the trainers as required by NASA; and at KSC to support final installation integration, checkout and launch operations. Logistics support will consist of spares provisioning, maintenance planning data and maintenance personnel support for each area where maintenance operations are required.

The approach selected for support of maintenance operations is a realistic tradeoff between minimum cost consistent with rapid system maintenance reaction time (ability to perform all possible maintenance tasks immediately and on location). The AAP-1A support approach initially provisions a minimum number of spare replacement items to support the expected frequency of maintenance/repair operations, based on a normal equipment operating schedule. The Martin Marietta factory rapid-reaction repair system shall be utilized for maintenance operations for which spares have not been provisioned or in the event all available spares have been expended. Rather than establish a complete spares inventory at each maintenance location, a single spares inventory will initially be stocked at Denver to support operations while the carrier is at that location. When the carrier is shipped to KSC, the complete spares inventory will also be transferred to KSC. Spares required to support operations at MSC will be provided (on request) from the inventory at Denver or KSC. High usage spares will be reprovisioned as necessary.

Corrective maintenance requirements other than spared replaceable items operations will be evaluated as they occur to determine the necessary corrective action - repair on location with available resources; repair on location utilizing mobile factory equipment and personnel; or return to factory for repair. Preventive maintenance will be scheduled and performed so as not to interrupt normally scheduled installation, buildup, integration, checkout and launch operations.

5.4.3 Carrier/SLA Accessibility - Personnel and support equipment access will be required to all areas of the carrier while installed within the SLA, at the MSOB and the launch pad. Specific program ground rules dictated the positioning of the carrier within the SLA and limited the modifications which could be made to the SLA structure and existing SLA internal work platforms. The carrier configuration and placement of equipment on/in the carrier determined the specific areas of the carrier assembly to which access would be required. This Accessibility Study was performed in conjunction with Report PR-29-40, Handling, Access and Transportation Evaluation.

SLA structure and installations drawings and the existing SLA internal platform set drawings were obtained and the interfaces and interferences with the proposed carrier configuration were studied. The levels of the existing platforms are suitable but since the carrier is considerably smaller and of different configuration than the LEM, the existing platforms do not closely conform to the carrier shape. Also, the carrier support arms interfere with one level of the existing platform set in three locations.

In coordination with North American Aviation personnel, proposals for modifying the existing platforms were evaluated. Minimum modifications to the existing platforms at the upper levels, and development of a "catwalk" type platform below the carrier would meet general requirements for access to the carrier. Also, the requirement to emplace and remove the platforms through the existing SLA and IU access doors would be met. Since the emplacement or removal of the entire platform set will require approximately six hours, only one segment of the platform just inside each SLA access door should be left in the SLA until late in the launch countdown. Any equipment/experiments which must be installed on the carrier late in the countdown must be designed to be positioned in an area of the carrier which is accessible from these two platform segments. An interference between the carrier and existing platforms can be resolved with a simple platform modification.

Selected thermal blankets will be constructed in relatively small, separately removable sections which can be installed late in the countdown.

Figure 5.4.-I shows the carrier installed within the SLA and the positioning of existing and proposed internal work platforms with workmen in typical locations for experiment and subsystem operations.

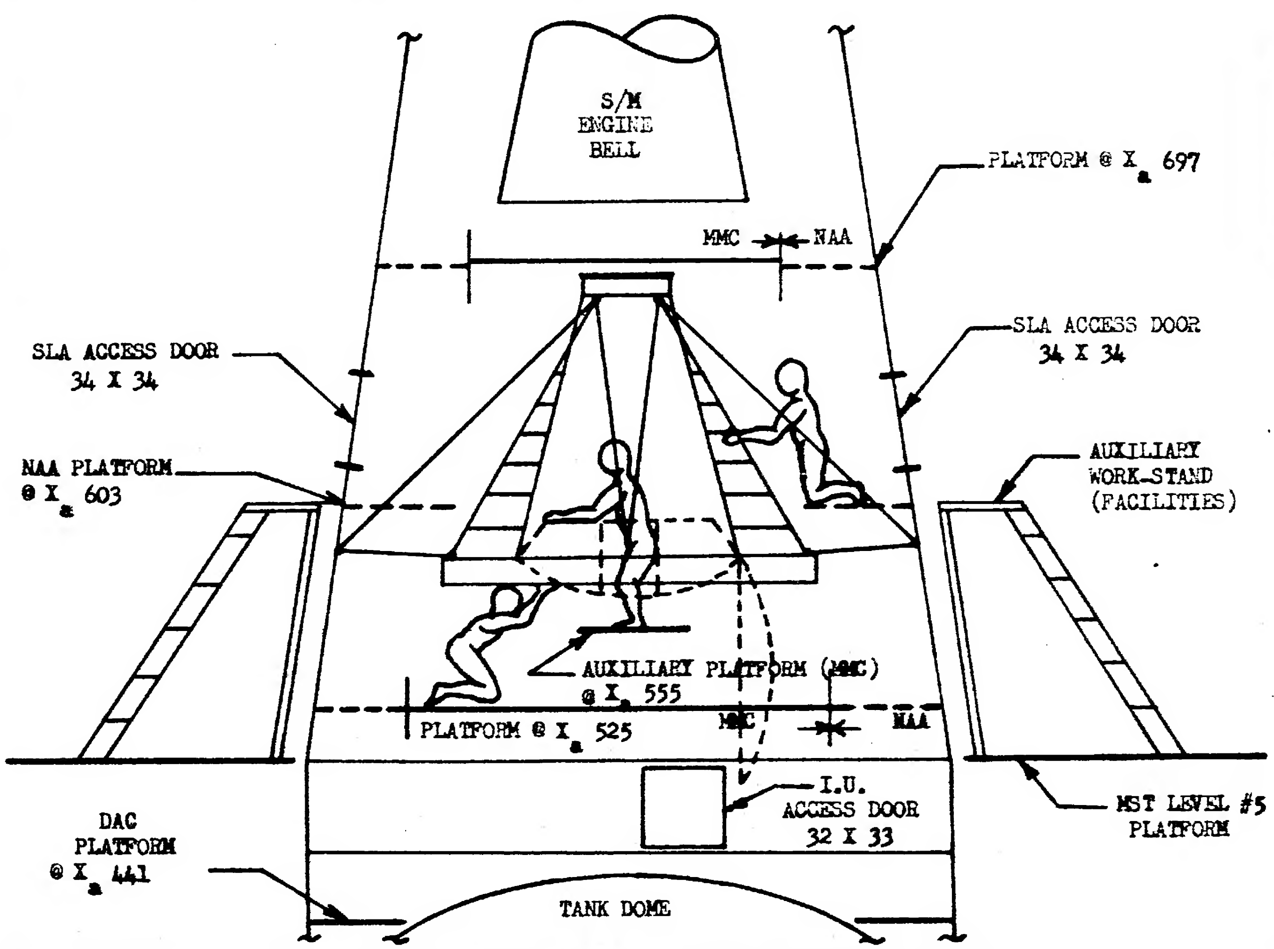


Figure 5-4-1, Carrier/SLA Accessibility/Interface

5.4.4 Maintainability Features - The support approach of sparing black boxes and removing and replacing equipment at that level to perform corrective maintenance causes the placement of these "black boxes" on the carrier to be especially important as a Maintainability feature. This particular aspect of system and subsystem design was analyzed to ensure that the heavier and less reliable modules were the most accessible and could be readily reached with auxiliary handling equipment.

System malfunction indication and isolation will be provided by the Digital Test Set described in study report PR-29-39, Ground Checkout Systems. The use of the DTS is an excellent system maintainability feature.

The time consuming task of realignment after component replacement will also be minimized by careful control of component interchangeability and of truss/alignment plate fabrication to minimize the use of adjustment devices as a part of component installation provisions.

Component and experiment calibration and servicing requirements on the pad will also be minimized by requiring these tasks to be performed primarily at the part level prior to installation on the carrier. On-pad operations then would be limited to a check of alignment and servicing at the subsystem or system level.

Individual component access will be enhanced by rack compartmentalization technique with a minimum arm reach. The paneling covering the outer racks will include several individually removable access doors attached with quick-release fasteners.

5.5 Mass Properties Analysis - This section presents the mass properties resulting from the trade and evaluation studies. The current predicted weight including a 5% growth allowance, is 5192 lbs. for the January mission and 5408 lbs. for the April mission. The center of gravity location is 13.2 inches forward of the SLA attach points and 1.3 inches radially from the centerline.

5.5.1 Carrier Weight Summary - Table 5.5-I is a functional type weight breakdown by subsystem for each flight.

5.5.2 Detail Weight Analysis - The detail weight analysis in Table 5.5-II shows the derivation of each of the subsystem weights. Refer to PR29-36, Mass Properties Report, for additional information.

Table 5.5-I

Carrier Weight Summary

	Launch Date	
	April (lbs)	January (lbs)
Structure	1167	1167
Electrical Power	1484	1484
Attitude Control	46	46
Data Management	333	290
Display and Control	178	178
Thermal Control	357	357
Subsystem Support	240	236
Sub-Total	3805	3758
Experiments	1218	1074
Experiment Support	125	110
Sub-Total	5148	4942
Growth Allowance	260	250
Total	5408	5192

Table 5.5.-II

Detail Weight Analysis

Structure

	Lbs.
Skin	94
Docking Ring and Fwd Frame	33
Longerons	27
Dome	40
Dome Flanges w/bolts	45
Windows w/frames	55
Airlock w/frames	53
Support Trusses	277
Truss Attach Ftgs.	21
SLA Attach Ftgs.	22
Internal Truss w/ftgs.	23
External Racks	137
Drogue Assembly	30
Contamination Covers & Mechanisms	75
Meteoroid Protection	40
Contingency	195
TOTAL	1167

Attitude Control

Horizon Scanners (2)	9
Electronics	10
Gyro & Electronics	15
Sun Sensors (4)	1
Wire, Connectors, Clamps, etc.	7
Contingency	4
TOTAL	46

Electrical Power

Batteries (7)	980
Inverters (2)	60
Switches (6)	21
Circuit Breakers	6
Diode Pkgs	20
Wire, Connectors, Panels, Busses, etc.	326
Contingency	71
TOTAL	1484

Table 5.5.-II (Cont'd)

Detail Weight Analysis

Thermal Control

	Lbs.
Active System	
Radiator	45
Pump Pkg	7
Freon Boiler	1
Cold Plates	79
Valves & Disconnects	2
Orifice	2
Accumulator	9
Lines & Fittings	22
Freon 21	100
Passive System	
Insulation	23
Attachments	25
Contingency	32
TOTAL	357

Display & Control

D&C Panel in CSM	85
CSM Wiring, Clamps, etc.	25
Control Logic	4
Sequencer	5
Display Logic	4
Carrier Wiring, Clamps, Busses, etc.	28
Contingency	27
TOTAL	178

Table 5.5-II (Cont'd)

Detail Weight Analysis

Data Management

	Lbs.	
Signal Conditioner	30	
PCM	35	
Recorder	15	
S-Band Xmtr	13	Remove for Jan. Fl't.
S-Band Pwr. Amp	24	
S-Band Signal Switch	1	
S-Band Antenna	1	
CTE	7	
VHF Xmtrs (3)	15	
VHF Amplifiers	2	
VHF Antenna	5	
S017 Data System	70	
Support Camera	35	
Wire, Connectors, Clamps, etc.	50	
Contingency	30	(26)
TOTAL	333	(290 for Jan. Fl't.)

Experiments

S039 Day-Night Camera	61	Remove for Jan. Fl't.
S040 Dielectric Camera	83	
S043 Infrared Temp. Sounder	45	
S044A Elec. Scan Micro Radiometer	20	
S048 UHF Sferics	31	
S017 X-ray Astronomy	222	
S019 UV Stellar	43	
S020 UV X-ray Solar Photo	25	
D017 CO_2 Reduction	32	
S015 Zero-g Single Human Cell	22	
T003 Inflight Nephelometer	5	
T004 Frog Otolith	86	
E06-1 Metric Camera	200	
E06-4 Multispectral w/extra film	55	
E06-9 Infrared Radiometer/ Spectrometer	80	
E06-7 Infrared Imager	120	
E06-11 Microwave Radiometer	50	
D008 Radiation	5	
D009 Simple Navigation	12	
S016 Trapped Particle	8	
S018 Micrometeorite	6	
T002 Manual Navigation	7	
TOTAL	1218	(1074 for Jan. Fl't.)

5.5.2.1 Structure - The structure weight breakdown includes the equipment racks, camera truss, meteoroid protection, and sensor contamination covers in addition to the basic carrier structure. The equipment racks, camera truss and basic carrier weights are derived from stress analysis. The meteoroid protection required is the result of a statistical analysis. The docking ring and drogue assembly weights are based on existing Apollo hardware. A suitable weight contingency factor based on MMC experience in similar designs is applied to total structure weight to allow for details not covered in the current data sources but required for design completeness. A detailed description of the structure configuration is in section 4.1.1.

5.5.2.2 Subsystems - The subsystem weights are based mainly on existing hardware with appropriate allowances for interconnecting wiring and plumbing. A few items such as cold plates in the thermal control area are development items. The experiment weights are based on existing hardware, modification of existing hardware or in some cases, redesign of components.

A contingency factor is included in the total weight for each subsystem (except experiments). A subsystem support weight for mounting equipment is included as a percentage of the overall subsystems weight.

5.5.3 Center of Gravity - The present ground rule for center of gravity (c.g.) location is that the c.g. be within a 36 inch radius sphere which has its center at the intersection of the SLA attach points and the booster axis. The c.g. analysis indicates the location to be 13.2 inches forward and 1.3 inches radially from this intersection point. The c.g. of the carrier/CSM combination must be within a cone which is within the control cone defined by the engine gimballing capability. The c.g. location meets these requirements.

5.6 Environmental Levels - The results of the preliminary analysis are presented in Table 5.6-I. These levels are representative of the carrier equipment in all phases of the mission from hardware acceptance through the re-entry phase. Equipment that is programmed for re-entry was analyzed and found to have a lesser environmental requirement during the re-entry phase than during the prior phases with the exception of acceleration in Table 5.6-I. Re-entry equipment would be under the classification of Control Module (CM) environments.

Vibration requirements indicated in Table 5.6-I have been determined from available data contained in North American Aviation document MC999-0051, "Apollo Environmental Design and Test Requirements". The vibration levels in Table 5.6-I were obtained from preliminary analyses of weight and structure configuration together with the levels contained in MC999-0051.

The indicated level of the deployable panels is 22.7 grms and the level of the Lunar Module is presented as 10.4 grms. The normal characteristics of negative attenuation have been applied to obtain the levels persented herein.

Table 5.6-I, AAP-1A Environmental Guide, Carrier Systems & Equipment (Preliminary)

PHASES	GROUND HANDLING STORAGE & TRANSPORTATION	LAUNCH & ASCENT	TRANSPOSITION AND DOCKING			ORBITAL OPERATION			RE-ENTRY
ENVIRONMENTS	(NON OPERATING)	Carrier; Interior & Exterior	Command Mod. Interior	Carrier Interior	Carrier Exterior	Command Mod. Interior	Carrier Interior	Carrier Exterior	CM Interior
TEMPERATURE	$-45^{\circ}F$ to + $160^{\circ}F$ - 100 hrs. Non Operating	$45^{\circ}F$ Increasing to $95^{\circ}F$ in 7 Minutes	$50^{\circ}F$ to $90^{\circ}F$ @ 5 Psia	$0^{\circ}F$ to + $150^{\circ}F$ @ 10^{-7} MM Hg	$0^{\circ}F$ to + $150^{\circ}F$ @ 10^{-7} MM Hg	$50^{\circ}F$ to $90^{\circ}F$	$32^{\circ}F$ to $85^{\circ}F$	$0^{\circ}F$ to $150^{\circ}F$ @ 10^{-7} MM Hg	$50^{\circ}F$ to $110^{\circ}F$ 2 Hours
ALTITUDE a) b)	a) 50K ft (3.42" Hq)-Air Trans. b) 10K ft (20.59" Hq)-Storage	760 to 10^{-7} MM in 7 Min.	5 Psia	10^{-7} MM Hq	10^{-7} MM Hq	5 Psia	5 Psia	10^{-7} MM Hg	5.0 to 14.7 Psia in 30 Min.
HUMIDITY	10 @ 24 Hr. Cycles Max of 160°F at 95% R.H./16 Hrs. Per Cycle	0 to 100% R.H.	0 to 100% R.H.	N/A	N/A	0 to 100% R.H.	0 to 100% R.H.	N/A	0 to 100% R. H.
SHOCK a) b)	a) Packaged/MIL-STD-810A,PRDC III b) Design-30g-½ sine- 11± 1 MS	30 g's ½ sine pulse - .4 ms.	600 g's-½ sine pulse - .4 ms.	325 g's-½ sine pulse - .4 ms.	600 g's-½ sine pulse - .4 ms.	N/A	N/A	N/A	78 g's Saw Tooth - 15 ms.
VIBRATION	Sine - 10 g's 0 to 200 cps	Random 12.9 GRMS for 7.5 min/axis	N/A	N/A	N/A	Random 3.5 GRMS	N/A	N/A	Random 5.8 GRMS 30 Minutes
ACCELERATION	2 g's Applied to All Reasonable Surfaces	12 g's-5 min/side	N/A	N/A	N/A	N/A	N/A	N/A	20 g's-5 Min. per side
SALT FOG (CORROSION) a) b)	a) 20% Salt Solution for 50 Hrs. (External Equipment) b) 10 Hrs. (Internal Equipment)	N/A	N/A	N/A	N/A	1% Salt Sol. 48 Hrs.	1% Salt Sol. 48 Hrs.	N/A	1% Salt Sol. 48 Hrs.
ACOUSTIC	N/A	(Interior) Liftoff: 141.5 db for 0.5 Min InFlight: 154.0 db for 2.0 min. (Exterior) Liftoff: 149.0db for 0.5 Min. InFlight: 156.5 db for 2.0 Min.	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RAIN	4±1 Inch/Hr. for 2 Hrs. non-Operating per 808B0026007 Para; 4.10	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
RADIATION	N/A	N/A	N/A	N/A	N/A	N/A	N/A	.305 Roentgens/hr for 14 days and 102.48 Roentgens total in 14 days	N/A
OZONE	12 Mo. Exposure including 3 Mo at 0.25 PPM, 72 Hrs. at 0.50 PPM, and balance at 0.05 PPM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
METEORID	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1% Erosion in 14 days	N/A
FUNGUS	808B0026007 Para. 4.12	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
OXYGEN	N/A	N/A	95±5% by wt.	N/A	N/A	95±5% by wt.	95±5% by wt.	N/A	N/A
EMI	N/A	MIL-6051	MIL-6051	MIL-6051	MIL-6051	MIL-6051	MIL-6051	MIL-6051	MIL-6051
SAND AND DUST	808B0026007 Para; 4.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

5.7 Interfaces

5.7.1 General -The AAP-1A mission studies performed during this period have disclosed several areas of interfacing hardware and joint operations with Apollo program contractors. Some of these are under the cognizance of more than one NASA Center. A well-defined interface control methodology is required to govern the identification, negotiation, approval, and documentation of the interface requirements and agreements between MMC, the Associate Contractors and NASA Centers involved. This methodology must utilize the present Apollo interface methodology and documentation insofar as feasible while still permitting visibility and control of the AAP-1A program interfaces.

The following paragraphs outline a plan for developing the interface documentation required and lists the interfacing areas and subjects identified to date. The plan is preliminary, and will be coordinated with NASA and subsequently published as a program control document.

5.7.2 Interface Documentation Development Plan -

5.7.2.1 The interface documentation plan was developed around the following assumptions concerning its relationship with the Apollo program.

- The Interface Control Document (ICD) will be the principal method for defining all mutual agreements between Associate Contractors and NASA Centers.

- The present methodology for document format and subject treatment will be followed. For example, Inter-Center ICD's will be guided by CM-001-001-1A, Apollo Inter-Center Interface Control and Repository Operations.

- Interface Revision Notices (IRN's) to existing ICD's will be prepared where feasible in preference to new ICD's.

5.7.2.1 (Cont'd)

- North American Aviation (NAA) will be responsible for the Carrier-to-CSM and Carrier-to-SLA ICD's and IRN's while MMC will be responsible for ICD's and IRN's covering the remaining interface areas listed in paragraph 5.7.3. It is recognized that NASA may elect to prepare ICD's in the areas where they act as an Associate Contractor.

5.7.2.2 MMC will prepare with NASA coordination, an Interface Control Requirements Document. This document will list the ICD's and IRN's expected to be generated and the responsible Contractor for each. The ICD preparation, negotiation and approval cycles will be defined. The ICD master numbering system and subject breakdown will be described. Procedures for processing changes to completed ICD's will be included. This document will serve as a reference guide for the interface documentation phase of the program.

5.7.2.3 In order to expedite identification and negotiation of technical interfaces affecting the design of the AAP-1A program hardware, MMC will prepare as early as feasible a set of Preliminary ICD's identifying program external interface requirements in each major interface area. These will be coordinated technically with the interfacing contractor for each ICD. Each will be a feasible interface arrangement based on available knowledge of interfacing hardware and operations.

5.7.2.4 Each major hardware interface ICD will be broken into subject areas to facilitate coordination and agreement. As many detail ICD drawings and specifications as are needed to cover each area will be prepared. The ICD numbering system will insure that each detail ICD is referenced to the complete area ICD.

5.7.2.5 The interface requirements for each ICD area will be divided into subject areas as follows:

a. Mission Operations Requirements

5.7.2.5 (Cont'd)

b. Environmental Limitations Requirements

c. Structural/Mechanical Requirements

d. Electrical Power and Signals Requirements

e. Fluid Requirements

f. Interface Testing Requirements

Within each of these areas, the ICD's may be narrowed further to separate pre-launch requirements from boost and orbit requirements.

5.7.2.6 The completed set of Preliminary ICD's will define the AAP-1A interface requirements and their effect upon the Apollo program and thus will serve as the basis for negotiation between NASA Centers and the contractors involved. The resulting agreements will be documented as formal ICD's and IRN's by NAA and MMC in their respective areas of responsibility.

5.7.3 AAP-1A Major Interface Areas

5.7.3.1 Implementation of the AAP-1A program will require reaching agreement in the following external interface areas:

Carrier to CSM
Carrier to SLA
Carrier to Crew Operations
Carrier to Crew Equipment
Carrier to MSFN
Carrier to Truth Site Network
Carrier to KSC GSE
Carrier GSE to KSC Facilities
Experiments GSE to KSC Facilities
Carrier GSE to KSC GSE
GFE Experiments to AAP-1A Mission

5.7.3.2 The limited studies performed have identified probable interface subjects in the above areas. As the AAP-1A studies continue, these interfaces will be further defined as specific interface requirements to be negotiated and controlled by the interface documentation program.

5.7.3.3 Major interface subjects to be further developed include the following:

5.7.3.3.1 Carrier-to-CSM Interface Requirements

- Carrier-CSM Structural Loads at Interface
- Carrier-CSM Docking Loads
- Carrier-CSM Docking Alignment Aids
- Carrier-CSM Probe/Drogue Interface
- CSM-Experiments Installation Provisions
- CSM-D&C Panels Installation Provisions
- CSM-Experiments Stowage Provisions
- Carrier-CSM Docking Umbilicals Arrangement
- Carrier-CSM Data Management Wiring Interfaces
- Carrier-CSM D&C Panels Wiring Interfaces
- CSM-Experiment Wiring Interfaces
- CSM-Carrier Pressurization Oxygen Allocation
- CSM-Carrier RCS Propellant Allocation
- Carrier-CSM Docking Test Operations
- Carrier-CSM Leak Test Operations
- Carrier-CSM Combined System Test Operations

5.7.3.3.2 Carrier-To-SLA Interface Requirements

- Carrier-SLA Structural Interface
- Carrier-SLA Space Envelope Limitations
- Carrier-SLA Separation System
- Carrier-SLA Loads and Stiffness Requirements

5.7.3.3.2 (Cont'd)

- Carrier-SLA Personnel Access Requirements
- Carrier-SLA Umbilical Access Requirements
- Carrier GSE-SLA Access Platform Load Points
- Carrier-SLA Criteria for Venting During Boost
- Carrier-SLA Environmental Interfaces
- Carrier-SLA Fit Check Operations at MSOB
- Carrier Air Conditioning Requirements During Transit
- Joint Usage of SLA Access Platforms at Complex

5.7.3.3.3 Carrier-To-Crew Operations Interface Requirements

- Crew Lighting Provisions in Carrier
- Carrier Internal Temperature Constraints in Orbit
- Crew Operations, Carrier Docking
- Crew Operations, D&C Panels Transfer to CM
- Crew Operations, Experiments in CM
- Crew Operations, Experiment in Carrier
- Crew Operations, Equipment Transfer for Re-entry
- Crew Operations, Pointing and Tracking
- Crew Operations, Simulation Training on Apollo Equipment

5.7.3.3.4 Carrier-To-Crew Equipment Interface Requirements

- Carrier Mounted Tether Assembly Set
- Crew Pressurization Suit Umbilical Extension

5.7.3.3.5 Carrier GSE-To-KSC Facilities Interface Requirements

- GSE Installation Provisions in MSOB
- GSE Installation Provisions in Launch Complex
- GSE to Facility Piping Interfaces
- GSE to Facility Power Interfaces in MSOB
- GSE to Facility Power Interfaces in Launch Complex
- GSE to Facility Fluid Interfaces at MSOB (He and GN)
- GSE to Facility Fluid Interfaces at Launch Complex
- GSE Range Commodities Requirements (LN_2 & Freon)
- GSE - Facilities Joint Operations for Carrier Installation in SLA
- GSE - Facilities Joint Operations for Experiments Installation in CM
- Joint Usage of Facilities Work Platforms at Complex

5.7.3.3.6 Experiments GSE-To-KSC Facilities Interface Requirements

- Experiments GSE Installation Provisions In Launch Complex
- Experiments GSE Facility Power Interfaces
- Experiments GSE Air Conditioning Requirements in Complex

5.7.3.3.7 GFE Experiments-To-1A Mission Interface Requirements

- Physical Mounting Arrangements in Carrier or CM
- Electrical Power Interface with Carrier or CM
- Data Handling Interface with Carrier
- Environmental Constraints during Operation
- Crew Operations of Experiment Controls

5.7.3.3.5 Carrier GSE-To-KSC Facilities Interface Requirements

- GSE Installation Provisions in MSOB
- GSE Installation Provisions in Launch Complex
- GSE to Facility Piping Interfaces
- GSE to Facility Power Interfaces in MSOB
- GSE to Facility Power Interfaces in Launch Complex
- GSE to Facility Fluid Interfaces at MSOB (He and GN)
- GSE to Facility Fluid Interfaces at Launch Complex
- GSE Range Commodities Requirements (LN_2 & Freon)
- GSE - Facilities Joint Operations for Carrier Installation in SLA
- GSE - Facilities Joint Operations for Experiments Installation in CM
- Joint Usage of Facilities Work Platforms at Complex

5.7.3.3.6 Experiments GSE-To-KSC Facilities Interface Requirements

- Experiments GSE Installation Provisions In Launch Complex
- Experiments GSE Facility Power Interfaces
- Experiments GSE Air Conditioning Requirements in Complex

5.7.3.3.7 GFE Experiments-To-1A Mission Interface Requirements

- Physical Mounting Arrangements in Carrier or CM
- Electrical Power Interface with Carrier or CM
- Data Handling Interface with Carrier
- Environmental Constraints during Operation
- Crew Operations of Experiment Controls

5.7.3.3.7 (Cont'd)

- Experiment GSE Installation
- Experiment Testing and Calibration

6. AAP-1A MISSION IMPACT ON BLOCK II SPACECRAFT

6.1 Summary - One of the objectives of the AAP-1A study was to conceive a feasible carrier system that would have a minimal impact on the basic Block II Command-Service Module and the Spacecraft LM Adapter. As the various subsystem reports have indicated, this objective has largely been accomplished. However, the large number of experiments and the unique requirements of certain experiments have necessitated recommending a systems approach that does require some supplementary changes to the basic Apollo spacecraft design. These changes are described in the following paragraphs.

6.2 Installation of Experiments in the CM - Some of the selected experiments for this mission were designed to be stowed and operated in the Block I Command Module. Others require the target viewing capability provided by the CM. These experiments have been specified for mounting in the CM and will require space allocation and installation bracketry. The experiments involved are S015, T002, T003, D008, D009 and the D&C unit of S017. The experiments also require 2.6 KWH of electrical power from the CM 28 vdc bus. Requested stowage locations in the CM for the AAP-1A mission are shown in Figure 3.2.6-1.

6.3 Stowage of Experiment Data in CM during Re-Entry - Successful completion of certain experiments require that the data obtained be returned to earth in the CM. Storage and restraint provisions must be made available in the CM. The study reported in Paragraph 3.2.6 indicated that sufficient volume and weight capability exist in the present Block II CM for data return from experiments S019, S020, S015, T003, E06-1, E06-4, E06-7, D008, D009, S016, S018, and T002 and the Support Camera. Restraint provisions will be required in suitable locations for the crew to transfer experiment modules from the carrier prior to re-entry.

6.4 Operation of Experiments from CM Work Stations - The optimum work station for controlling most of the experiments was recommended to be the pilots couch in the CM. Therefore, a portable Display and Control panel will be provided for mounting on temporary brackets in the cutout area above the center couch.

6.4 (Cont'd)

The panel will be transferred to this location after docking and carrier separation from the SLA. An interconnecting cable must be routed to the docking ring interface connector, where it will be interchanged with the existing cable carrying the SLA separation circuitry.

6.5 Pilot Operation of Carrier Experiments from Carrier - Operation of some of the experiments requires a crew work station in the forward end of the carrier. To provide a working environment in the carrier requires extending the length of the suit umbilical from 119 to 144 inches, to maintain oxygen, communications and biomed circuits. Additional oxygen is also required from the CM to pressurize the carrier pressure vessel for crew occupancy.

6.6 Interconnection of Carrier Data System with CM Data System - Experiment T004 requires a capability for being turned on and data dump commanded by ground control during crew sleep periods. Other experiments require voice annotation by the crew. To keep electrical interfaces to a minimum, the voice annotation requirement will be satisified by post-flight time correlation of CM voice recordings with recordings of experiment data. Four wires will be required to interface with the carrier to provide up-data link signals from the CM telecommunications system. These will be routed through the existing interface connectors in the docking ring.

6.7 Addition of "Hard Points" in the SLA - Personnel access to the carrier during launch vehicle checkout periods at the launch complex will require new access platforms within the SLA. These platforms require 24 attachment points on the SLA structure to support the platforms and associated tie-rods. These "hard points" can be identical in construction to existing SLA fitting adapters and could be added to the SLA after fabrication.

6.8 Mission Duration Impact on CSM Consumables - The AAP-1A mission has been planned for 14 days duration to achieve a maximum amount of experiment data for evaluation by experiment managers. It is recognized, however, that 14 days in earth orbit is not a requirement upon the CSM design and may demand a total load on CM consumables that would exceed the design capacity. Therefore, the mission was designed open-ended to 14 days. If CSM limitations

6.8 (Cont'd)

force a reduction in the maximum mission duration, appropriate changes will be made in the mission timelines. Size and complexity of the carrier support subsystems will be reviewed and corresponding changes incorporated.

The critical consumable appears to be cryogenic oxygen in the CSM. The pressurized carrier concept will require an additional oxygen demand of 40-50 lbs from CSM supplies. The experiment tracking and pointing requirements impose an additional load on the G&N system usage of electrical power.

7. ENGINEERING TESTING

7.1 Introduction - In the area of engineering test and quality assurance the primary study effort was directed toward structuring an integrated carrier test flow and management concepts which would establish confidence in the flight vehicle and experiments to perform their intended function. System design requirements and performance demands were reviewed and criteria were formulated which will be the basis for more detailed specification test requirements and test plans.

The principal governing factors that influenced this test definition effort were the requirements imposed by crew safety and primary mission objectives. Secondary considerations which were dictated by systems engineering analysis, including maximum use of previously qualified hardware and test experience, the reduction of test duplication, and the employment of system level tests as opposed to extensive sub-system testing.

The quality control aspects of the program were reviewed only from the standpoint of the need for a comprehensive failure analysis and corrective action procedure which will be developed to complement the engineering qualification program.

7.2 Test Flow - The overall verification test approach which has been developed for the AAP-1A experiments carrier is depicted in Figure 7.2-1. The test categories shown are those generally identified as: development on breadboard configurations; verification on production prototype units; and qualification on accepted production units.

In the design criteria for new carrier components, it shall be specified that piece-parts will be selected from those identified in the Martin Marietta Corporation Approved Components and Parts List for New and Modified Designs. Utilization of this criteria will assure that piece-part reliability is consistent with carrier reliability goals and predictions.

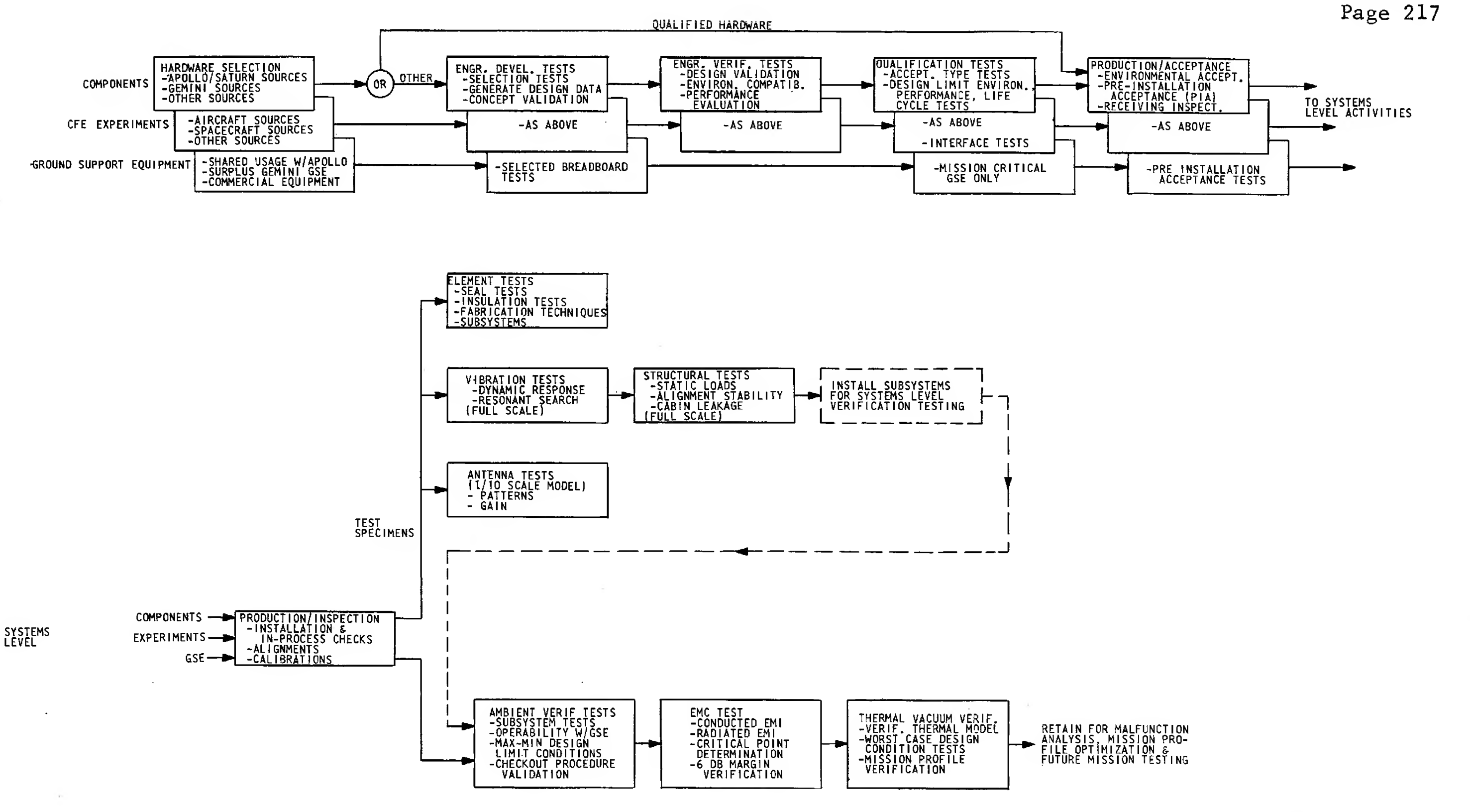


FIGURE 7.2-1
ENGINEERING TEST PROGRAM FLOW
(IA CARRIER)

7.2 (Continued)

At the component level of testing, the sequence shown is idealized. Each component selected for use will be analyzed to determine the extent of qualification reverification or new testing required to establish confidence that designs are adequate for the carrier environment and the AAP-1A mission sequence. This report will summarize the preliminary results of this analysis and it reflects the initial component qualification baseline. Experiments are treated in the same manner as components in that qualification of each individual experiment to operational environments is necessary.

Testing above the component level has been reduced to a minimum. The most significant tests will be those required to verify fabrication techniques and antenna patterns; performance tests on a thermal control subsystem (TCS) functional mock-up; and static load and dynamic response tests on the basic structure. To keep test hardware requirements to a minimum, the structural tests will be performed on the same test article that subsystem and system verification tests will be performed. During the structural static load and low level resonant search tests, subsystem and experiment equipment mass simulators will be employed. Static load tests of the truss support structure will verify its ability to withstand ultimate loads. Pressure testing (Ultimate) will be performed on the pressurized carrier enclosure. Window, hatch seal and scientific airlock leakage rates will be determined at operating pressure. This will include the affects of high and low temperatures if rubber-base seal materials are utilized.

The TCS functional mock-up tests will be performed in a laboratory environment utilizing qualified components where schedules permit. The primary objectives of this test sequence will be evaluation of orifice sizes and installation methods and the determination of subsystem pressure loss and flow characteristics. Additional supporting tests relating to the selection of a radiator coating and the determination of the physical properties of Freon 21 over a wide range of operating temperatures will be undertaken.

7.2 (Continued)

Subsystem and system level tests will be conducted on a test article which will be identical to the flight article in all respects except for experiments. A test goal will be to utilize all qualified subsystem components during this series of tests. The performance of each subsystem will be evaluated against its specification and handling and servicing techniques will be developed during this sequence of tests. Flight article acceptance test procedures will be validated. A thermal-vacuum test program to verify the carrier thermal model (including several sequences) of approximately fourteen days duration will include the operation of the carrier thermal control system under "worst case" conditions and the performance evaluation of all subsystems. Experiment simulators of suitable design to verify thermal control system performance will be employed.

Electromagnetic compatibility testing of the carrier during verification testing will consist primarily of verifying noise margins on power busses. Critical test point monitoring will be defined as design develops.

7.3 Qualification Baseline - Determination of the carrier qualification baseline is being established by analyzing each component in light of its previous test history and the anticipated carrier natural and induced environments (refer to PR 29-49 Carrier Equipment Acceptability Preliminary Data Review). Table 7.3-I is a summary of subsystem component qualification status. The data indicates where testing or analysis is required to verify design adequacy. Table 7.3-II presents similar information for the proposed experiments. The data presented in both figures is preliminary in nature and will be updated as designs are established and more detailed vendor data is received.

7.4 Critical Qualification Considerations - The following areas are those which will require primary attention as carrier development continues:

- Non-metallic Material Evaluation - Studies are in progress to determine the extent to which redesign and retest will be necessary to

Table 7.3-I Carrier Component Qualification Review

Sub-System	Component Name	Part No.	Critical Test Requirement	Remarks
Crew Equipment & Structures	Tether Assembly, Carrier Mounted	TBS	Complete Qual Program	New Design
	Tether Assembly, Crew Mounted	TBS	Pressure Test	Modified Design, GFP
	Carrier Structure, Basic	TBS	Complete Qual Program	New Design
	Device, Contamination Control	TBS	Complete Qual Program	New Design
	Drogue & Latches	TBS	TBS	Modified Design, GFP
	Seal, Dome (7' Dia)	TBS	Complete Qual Program	New Design
	Dome, Spherical Segment	TBS	Pressure Test	Modified Design
	Window Set	TBS	Complete Qual Program	New Design
	Airlock Set, Scientific	TBS	TBS	NAA Equipment, GFP
	Passive TCS	TBS	TBS	TBS
Thermal Control	Radiator Set	TBS	Complete Qual Program	New Design
	Pump Package	TBS	Vibration & Shock Compatibility	Modified Design, Hamilton Std
	Valve, Thermal Control	640805	Compatibility	Modified Design, Garrett
	Boiler, Freon	SV715715-1	Vibration & Shock	Modified Design, Hamilton Std
	Plate, Cold	TBS	Complete Qual Program	New Design, MMC

Table 7.3-I (Cont'd)

Carrier Component Qualification Review

Sub-System	Component Name	Part No.	Critical Test Requirement	Remarks
	Valve, Hand	828570	Vibration & Shock Compatibility	Modified Design, Garrett
	Quick Disconnect, A/B Half	SV715067	Vibration & Shock Compatibility	Ham.Std. Equip. Existing Design
	Quick Disconnect, Ground Half	SV715062	Compatibility	Ham.Std. Equip. Existing Design
	Accumulator	SV715380	Vibration & Shock Compatibility	Modified Design, Hamilton Standard
Data Management	Signal Conditioner & Distribution Unit	TBS	Complete Qual Program	New Design, MMC
	Encoder, PCM (5.12 KBS)	TBS	TBS	Modified Design, EMR
	Recorder, Tape	TBS	TBS	RCA Existing Design
	Transmitter, VHF	TBS	Vibration & Shock	IERC Existing Design
	Transmitter, S-Band	TBS	Vibration & Shock	Collins Existing Design
	Antenna, VHF	TBS	Vibration & Shock	Collins Existing Design
	Antenna, S-Band	TBS	Vibration & Shock	Collins Existing Design
	Power Amplifier, S-Band	TBS	Vibration & Shock	Collins Existing Design

Table 7.3-I (Cont'd)
Carrier Component Qualification Review

Sub-System	Component Name	Part No.	Critical Test Requirement	Remarks
	Equipment, Central Timing	TBS	Vibration & Shock	General Time Existing Design
	Multiplexer, VHF RF	TBS	Vibration & Shock	Collins
	Encoder, PCM	TBS	TBS	TBS
Display and Control	Panel, Display & Control	TBS	Complete Qual Program	New Design MMC
	Control & Distribution Center	TBS	Complete Qual Program	New Design MMC
Electrical Power	Battery	LPS-390-22C	Temperature and Shock	Modified Design Eagle Pitcher
	Inverter, Static	TBS	Vibration & Shock	Bendix Existing Design
	Shunt	92D18	TBS	MMC Existing Design
	Switch, Motor Driven	PD72S0068	TBS	MMC Existing Design
	Sensor, Undervoltage	TBS	Vibration & Shock	Existing Design
	Breaker, Circuit	TBS	TBS	Modified Design Mechanical Products
	Diode	IN3909	TBS	Westinghouse Existing Design
	Assembly Set, Harness	TBS	Complete Qual Program	New Design MMC
	Panel, Light Control	TBS	Complete Qual Program	New Design MMC

Table 7.3-I (Cont'd)

Carrier Component Qualification Review

Sub-System	Component Name	Part No.	Critical Test Requirement	Remarks
	Panel, Circuit Breaker	TBS	Complete Qual Program	New Design MMC
Local Vertical Control	Scanner, Horizon	TBS	TBS	Existing Design
	Gyroscope Package	TBS	Complete Qual Program	New Design
	Control Electronics Package	TBS	Complete Qual Program	New Design

Table 7.3-II Carrier Experiment Qualification Review

Experiment Name	Ref. Desig.	Identifier	Critical Test Requirements	Remarks
Radiation	D008	--	TBS	Existing Equipment-GFP
Simple Navigation	D009	--	TBS	Existing Equipment-GFP
CO_2 Reduction	D017	--	TBS	Existing Equipment-GFP
Metric Camera	E06-1	291801	Complete Qual Program	Fairchild (F639A)-CFE Modified
Multispectral Camera	E06-4	--	TBS	Existing Design-GFP
Infrared Imager	E06-7	291803	TBS	Singer (Reconofax II) CFE Modified
Infrared Radio-meter/Spectrometer (Sensor)	E06-9a	291804	TBS	Perkin-Elmer (SG-4)-CFE Modified
Infrared Radio-meter/Spectrometer (Electronics)	E06-9b	291804	TBS	Perkin-Elmer (SG-4)-CFE Modified
Multifrequency Microwave Radiometer	E06-11	291805	TBS	Space General Design-CFE Modified
Zero-G Single Human Cell	S015	--	TBS	Existing Equipment-GFP Texas Instrument
Trapped Particle Asymmetry	S016	--	TBS	Existing Equipment-GFP Space Science Lab
X-Ray Astronomy	S017	--	TBS	Existing Equipment-GFP
Micrometeorite Collection	S018	--	TBS	Existing Equipment-GFP Dudley OBSV
Ultraviolet Stellar Astronomy	S019	--	TBS	Existing Equipment-GFP Cook Electric
Ultraviolet X-Ray Solar Photography	S020	--	TBS	Existing Equipment-GFP Naval Res. Lab.

Table 7.3-II (Cont'd)

Carrier Experiment Qualification Review

Experiment Name	Ref. Desig.	Identifier	Critical Test Requirements	Remarks
Day-Night Camera	S039	--	TBS	Existing Equipment-GFP Hazeltine
Dielectric Tape Camera	S040	--	TBS	Existing Equipment-GFP RCA
Infrared Temperature Sounding (Radiometer)	S043	291806	TBS	JPL Design-CFE Modified
Infrared Temperature Sounding (Electronics)	S043	291806	TBS	JPL Design-CFE Modified
Electrically Scanned Microwave Radiometer	S044A	--	TBS	Space General Design-GFP Modified
UHF Sferics Detection (Antenna)	S048	291807	TBS	Space General Design-CFE Modified
UHF Sferics Detection (Receiver/ Electronics)	S048	291807	TBS	Space General Design-CFE Modified
Manual Navigation Sighting	T002	--	TBS	Existing Equipment-GFP
Inflight Nephelometer	T003	--	TBS	Existing Equipment-GFP
Frog Otolith Function	T004	--	TBS	Existing Equipment-GFP

conform to new NASA specifications. These specifications will be imposed as required on components, however, the impact on design is not yet known.

- Freon 21 Compatibility - Verification that TCS components are compatible with this fluid is necessary. This condition is critical in that a number of components fall in this category.

- Component Dynamic Response - Preliminary vibration and shock data for carrier truss mounted equipment reflects levels which are higher than the qualification levels imposed on LM and CM components. The impact of this situation will not be known until carrier design becomes better defined.

7.5 Failure Reporting, Analysis and Corrective Action - The system and procedures being developed for performing this quality control function are an extension of those which proved extremely effective in the NASA Gemini program. The system provides for early detection, reporting and correction of conditions adverse to product quality; and it provides positive control over any item which could degrade the probability of mission success. The system establishes visibility of problems to contractor management through the use of a Corrective Action Control Center. It also allows rapid definition and communication of significant problems to responsible customer (NASA) personnel. The system having proven successful on Gemini is now in effect on other contractor programs.

The basic principles of this procedure require the contractor to identify each non-conformance condition, including test variations from specifications, to the Corrective Action Control Center at the time of occurrence. A notification can originate from suppliers of critical hardware, factory areas, and field sites, and must be followed by the documentation of the non-conformance. Upon initial receipt of the notification in the Control Center, each condition is analyzed and posted as an Impact or Routine Problem. An Impact problem is defined as a problem which

affects hardware in being, or in a state of immediate production or procurement. A corrective action engineer is assigned for each Impact problem to determine the extent of failure, isolate the cause, establish component failed-part analysis requirements, and recommend problem disposition action. He directs corrective action assignments to all operating departments as applicable to the given problem and its close-out. Routine problems are assigned upon receipt of a Martin Marietta Automatic Reporting System (MARS) form to a Corrective Action Engineer for review, automatic closure or corrective action accomplishment. Problem history sheets are initiated for "Impact" problems. Inputs other than MARS forms, such as suspect material reports, flight and countdown problems, supplier-identified problems, reliability analyses, and maintainability analyses, are included in this history. Investigation analysis and corrective action associated with such problems follows the procedure described above. This system for failure and discrepancy reporting and corrective action provides:

1) Rapid identification of problems;

2) Effective follow-up to closure;

3) High visibility of problems requiring management attention;

4) Ability to rapidly assess total program hardware problems prior to an event such as a launch;

5) A centralized agency to provide correct and timely communication to affected customer agencies.

GROUND OPERATIONS AND GROUND SUPPORT EQUIPMENT

8. GROUND OPERATIONS AND GROUND SUPPORT EQUIPMENT

8.1 Introduction - The ground operations and GSE requirements necessary to support an early 1969 AAP-1A launch have been identified. Baselines have been established for:

- Denver Flight Article Acceptance Sequence
- KSC Ground Operations Sequence
- Denver and KSC Ground Support Equipment

This information was in turn used to (1) determine the impact on AAP-1A program costs and schedule, (2) provide the data required for Phase D engineering and material estimates, and (3) identify those areas which require further analysis and decisions prior to a Phase D go-ahead.

8.2 Study Approach - A flight article ground operations flow was developed to define the sequence of events involved in fabrication, acceptance test, transportation, pre-launch and launch of the AAP-1A flight article. The approach is to (1) integrate the AAP-1A carrier into the KSC Saturn/Apollo launch operation with minimum cost and schedule impact, (2) use existing Denver and KSC facilities and support operations whereever possible, (3) provide systems flexibility to accommodate late changes in experiment and subsystem installation and checkout, and (4) optimize GSE selections by considering available Apollo line equipment. This flow was generated in two phases: Denver Flight Article Acceptance Testing and KSC Ground Operations.

Each phase of the ground operations flow was analyzed in detail by GSE design engineers (checkout, servicing and handling/transportation) to identify GSE general functional requirements. From each general functional requirement, specific technical design requirements were derived. At this point in each design area, candidate design approaches capable of meeting the technical requirements were conceived, trade studies were performed in areas where more than one approach was feasible, and finally end items were selected which were capable of implementing the functional requirement.

8.2 (Cont'd)

This reasoning and selection process was performed for each GSE category and tabulated in matrix format in the following study reports:

- PR29-39, Ground Checkout Systems
- PR29-40, Handling, Access and Transportation Evaluation.
- PR29-22, Ground Servicing Systems.

Table 8.2-I shows a typical functional analysis approach in matrix format for specific AAP-1A GSE.

The output of this effort was a composite AAP-1A GSE end item list. Data sheets were generated for each end item to provide that information necessary for Phase D engineering estimates, hardware development and manufacturing costs.

8.3 Ground Operations Analysis - An AAP-1A ground operations baseline has been developed to delineate a logical flow of operations for the carrier, experiments and GSE from completion of manufacture through launch.

Figure 8.3-1 presents a summary of the operations associated with assembly, test and acceptance of the flight article at Denver. Figure 8.3-2 presents a summary of the KSC receipt-to-launch operations involving the integrated carrier during final experiment installation, docking tests, spacecraft build-up, launch vehicle mating and launch.

A brief timeline analysis was performed to prove feasibility of supporting the AAP-1A program scheduled launch. A February 69 launch can be supported by using a normal 4 month KSC Apollo operations schedule; however, to support a January 69 launch would require a three month KSC schedule with the first 50 working days on a two-shift operation.

8.4 Ground Support Equipment Analysis

8.4.1 Ground Servicing Systems - The AAP-1A carrier subsystems require leak checking, coolant servicing,

TABLE 8.2-I
GROUND SUPPORT FUNCTION/EQUIPMENT MATRIX

OPERATION/ LOCATION	FUNCTIONAL REQUIREMENTS	TECHNICAL DESIGN REQUIREMENTS	DESIGN APPROACHES	COMPARISON OF APPROACHES						RECOMMENDED APPROACH/EQUIPMENT	REMARKS
				EXIST EQUIP NO MOD	EXIST EQUIP PLUS MOD	EXIST DESIGN NEW BUILD	MOD DESIGN NEW BUILD	NEW DESIGN NEW BUILD	COST (ENGR. ESTIMATE)		
Carrier - Subsystems Checkout at SATF Integ. Carrier IST(Function-ally) at SATF Integ. Carrier Subsystem Functional Tests at MSOB A & T Area	Provide fluid services for Thermal Control System (TCS)	1. Flush fluid portion of TCS prior to filling with coolant 2. Evacuate fluid portion of TCS to (TBD) mm of Hg. 3. Fill TCS with approx. 100 lbs. of coolant 4. Drain coolant from TCS 5. Dry TCS and blanket with nitrogen at 5 psig	1. Provide new-design unit to perform all required functions					X	35K	Provide new-design Coolant Service Unit MMC Code No. 3101. This unit will provide flush, evacuate, fill, drain, dry and blanket functions. Flex lines and connectors will be included with the unit.	1. Unit will be similar in concept and size to 80801C10900 2. Providing a vacuum unit separate from coolant unit would complicate the servicing operations and also cost more.
			2. Modify Titan III Propellant Servicing Unit 80801C10900 design and build new unit				X		40K		
			3. Provide new-design coolant unit and separate vacuum unit					X	40K		
SATF after Electrical System Pre-Power Tests, MSOB, Vacuum Chamber, and LC-34	Verify Functional Performance of Airborne Subsystem Components	1. Data Management Subsystem Encoder: Provide electrical stimulus inputs and read digital data of 0.1% 108 0-5 VDC 96(191) 0-40 MVDC 1 24-Bit Serial 32 Bi-level Parallel	1. Digital Test Set Limited Decomm	X			X		Basic Unit GFP	Digital Test Set. This equipment reduces test time, provides greater test flexibility allows immediate recall of previous test results and excellent test configuration control.	Mods needed to DTS to improve accuracy and accept PCM Decomm input. May be off line with DTS Must be on line for manual
			2. Input/Output Box					X			
			Voltmeter	X							
			Power Supply (2)	X							
			Ground Station								
		2. Power Distribution Subsystem Battery Supply: Provide a tester for the airborne batteries to a. Verify battery heaters operation b. Check pressure decay rate c. Check voltage underload	1. Provide a Battery Load Test Set as designed for TIIIM (F10D01)				X			Battery Load Test Set	TIIIM unit is self contained. Design is existing and available.
			2. Provide Separate Test Instruments.								
SATF - Integ. Carrier System Build-up, Sub-system Test and Integ. Systems Functional Test	Support Installation of Carrier Subsystems	Hoist, Locate and Position Radiators, Dome, Encoder, Freon Boiler, S017 X-Ray Sensor & Electronics, Di-electric Tape Camera, UV Stellar Astronomy Camera & the UV Solar Photography experiments. Provide access to each component location.	Provide Hoisting Tray			X			2K	Hoisting Tray #3307 Platform Truck #3304 Subsystems Sling Set 5-Ton Hydra-Set B-1 Access Platform Mobile Work Stand Experiments Grips & Slings Set.	1. Hydra-Set is a Facility Item 2. Access Platform and Work Stand are GFE Items
			Provide Platform Truck			X			1K		
			Provide Subsystem Sling Set					X	2K		
			Provide Hydraset	X							
			Provide Access Platform	X							
			Provide Mobile Work Stand	X							

SATF - Spacecraft Assembly and Test Facility

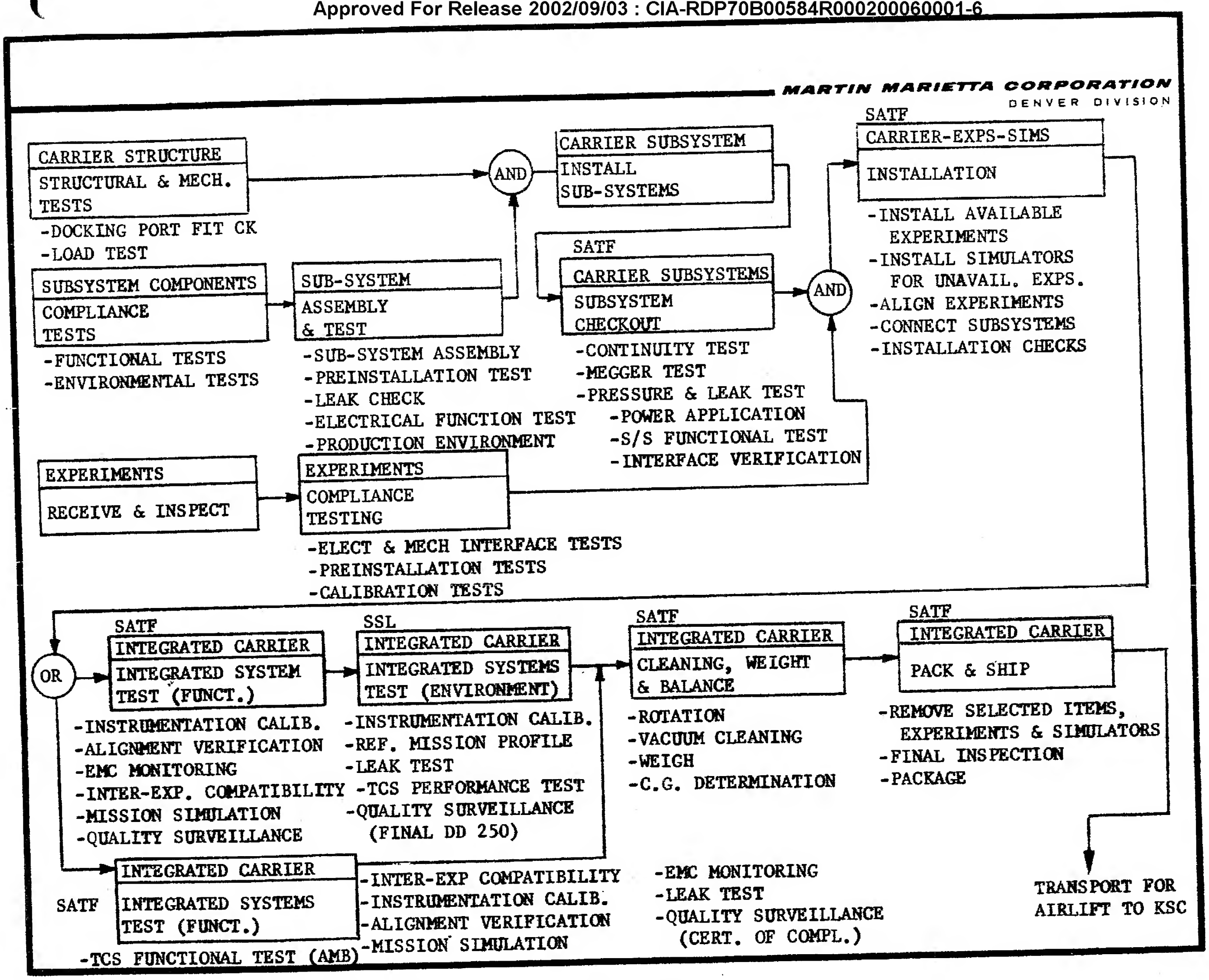


Figure 8.3-1, AAP-1A Ground Operations, Denver Acceptance

1A CARRIER KSC GROUND OPERATIONS

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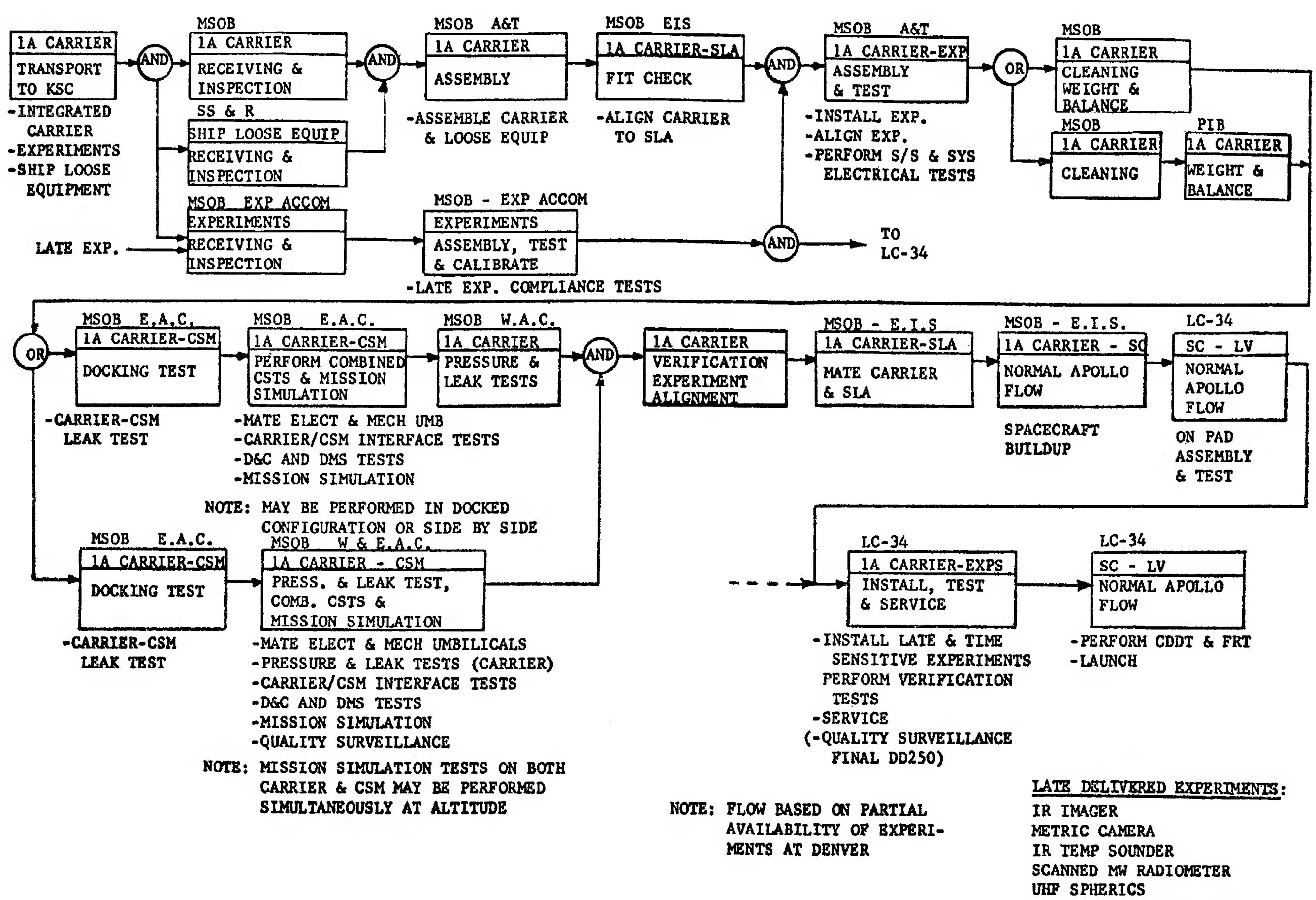


Figure 8.3-2, AAP-1A Carrier KSC Ground Operations

8.4.1 (Cont'd)

Freon servicing, vacuum servicing, and thermal simulation. The AAP-1A experiments require liquid nitrogen, vacuum, gaseous carbon dioxide, air conditioning, leak checking, and black body calibration. The gaseous requirements are minor and will be identified as program support requirements. The thermal simulators will be supplied as test tooling. All other requirements will be met by servicing GSE. Analyses and trade studies were performed to identify the equipment necessary to meet these requirements. The results have been tabulated in Study Report PR29-22, Ground Servicing Systems. The following is a brief functional description of each end item:

- A Coolant Service Unit provides for flushing, evacuating, filling, draining, drying, and blanketing of the Thermal Control System (TCS).

- A Freon Supply Unit delivers Freon to the TCS Freon boiler to dissipate the TCS heat load during ground operation.

- A Leak Check Unit and a Mass Spectrometer are used for leak checking the fluid portion of the TCS, the carrier structure, and the carrier-CSM interface.

- A Liquid Nitrogen Service Unit provides liquid nitrogen for checkout of several of the experiments.

- A Vacuum Service Unit is used to evacuate the spring sides of the TCS accumulators and for ground checkout of several experiments.

- An experiment Black Body Calibration Unit provides a cryogenic calibration standard for two of the experiments.

- A SLA Air Conditioner services the carrier-SLA during outdoor transit to maintain the experiments within their survival limits.

- A Carrier Umbilical Set and a Freon Distribution System provide the necessary equipment, such as flex hoses and connectors, to connect the servicing equipment to the TCS and experiments.

8.4.1 (Cont'd)

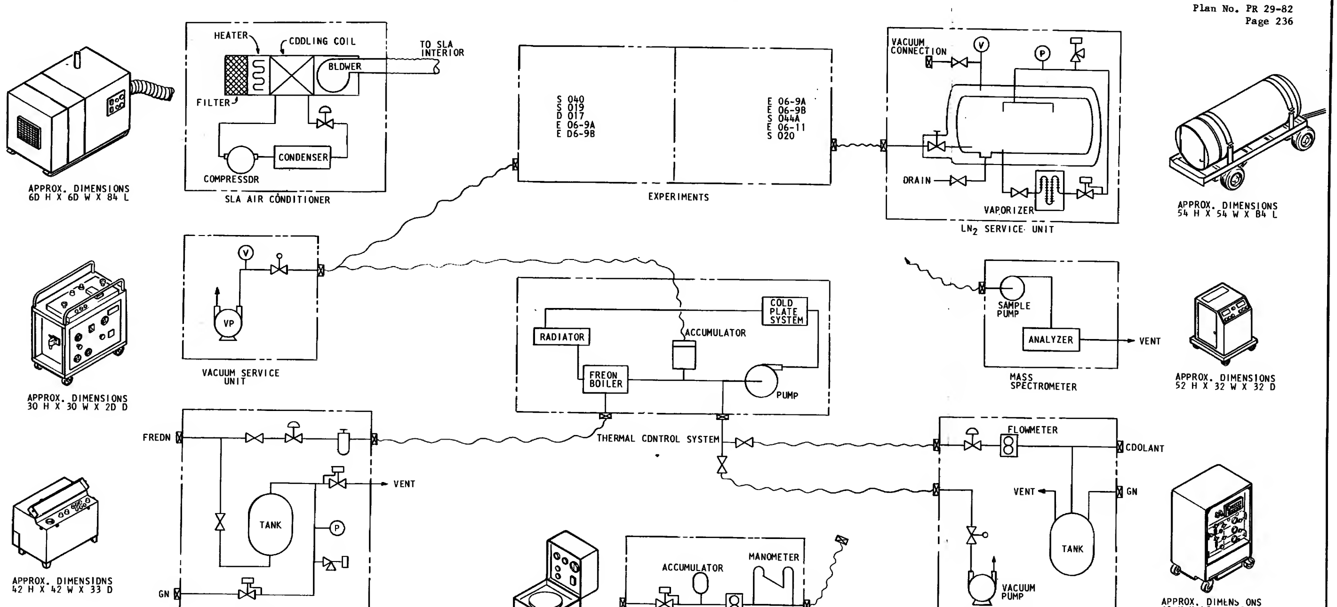
In order to minimize cost, existing engineering will be used for several of the above items. A single set of the above equipment will be provided for use first at Denver and then at KSC.

No major problem areas have been identified during this study. A timeline analysis should be performed to determine existing Apollo equipment that will be available for AAP-1A on a sole usage or joint usage basis. Figure 8.4-1 depicts the servicing equipment schematically and shows its relationship to the Thermal Control System and the experiments.

8.4.2 Ground Checkout Systems - A summary of the AAP-1A checkout system baseline is shown pictorially in Figure 8.4-2. A composite list of the checkout system end items is provided in Table 8.4-I.

The significant trade studies performed were (1) manual vs automatic checkout, and (2) provisioning of Denver and KSC TM ground station. An automatic checkout system was selected, primarily in order to meet accelerated AAP-1A schedule and provide maximum test flexibility. Details of this trade study are contained in PR 29-39, Ground Checkout System.

The digital test set will be used to perform automatic component, subsystem and combined system test. The DTS was designed and developed by Martin Marietta Corp. for NASA-MSC under contract NAS 9-6630. The prototype complete with a GFP CDC 160 computer is operational. MMC would request usage of this equipment for Denver and KSC checkout. The basic DTS will be supplemented by (1) a limited decommutator, (2) a power distribution and control rack, (3) a pre-detection tape recorder, (4) a remote D & C panel, and (5) standard laboratory test equipment. The system will be packaged in standard portable racks which will be used at Denver and then transported to KSC for use within the MSOB and at the launch stand. The system is connected to airborne components through multi-conductor cables. Memory and control functions are performed by use of the computer and its peripheral software. Checkout will consist of sequencing a series of pre-stored operations, performing the necessary computations to analyze component or system performance, and then providing a visual indication of system status.



MARTIN MARIETTA CORPORATION
DENVER DIVISION

FIGURE 8.4-1 GROUND SERVICING SYSTEMS

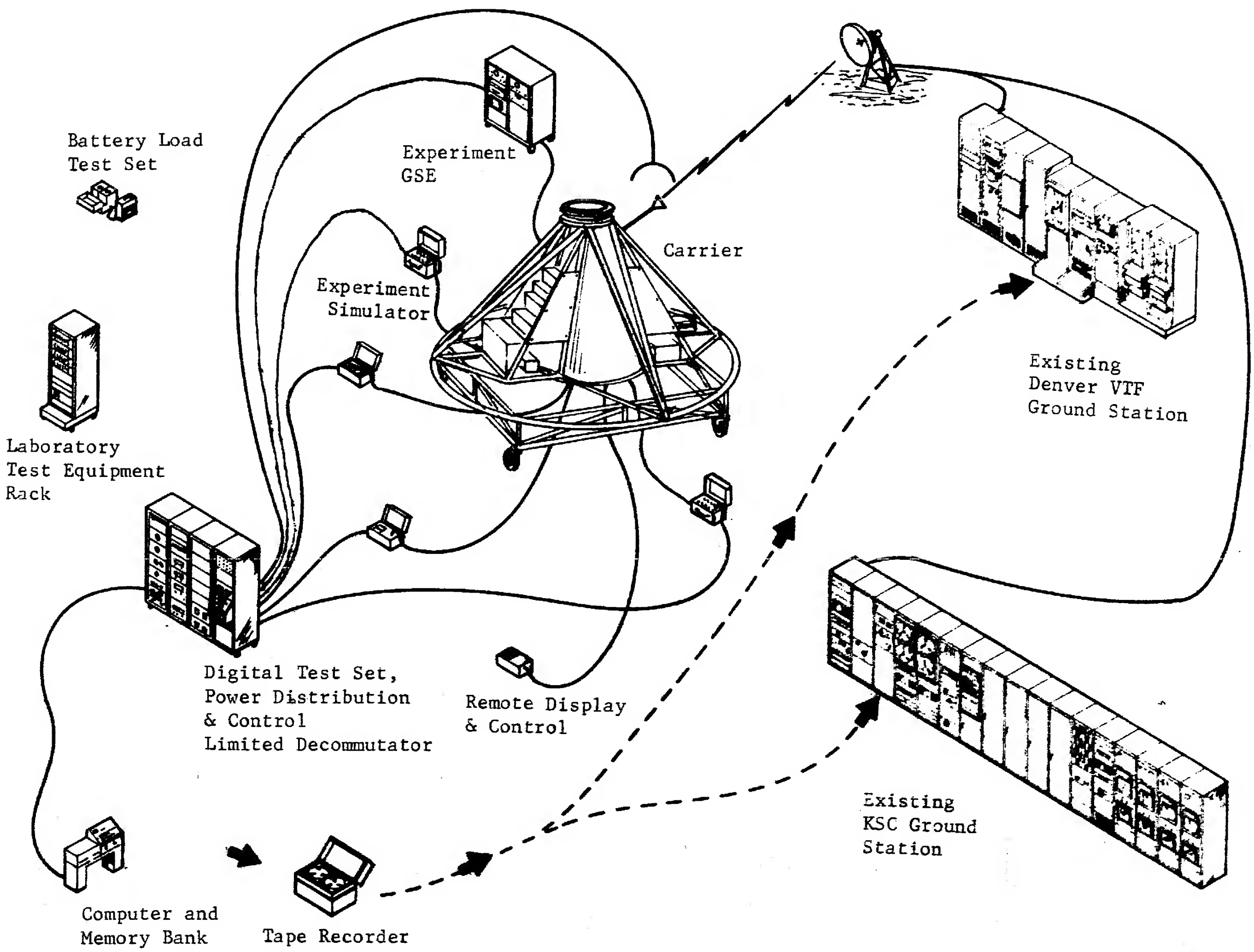


Figure 8.4-2 Ground Checkout Systems

8.4.2 (Cont'd)

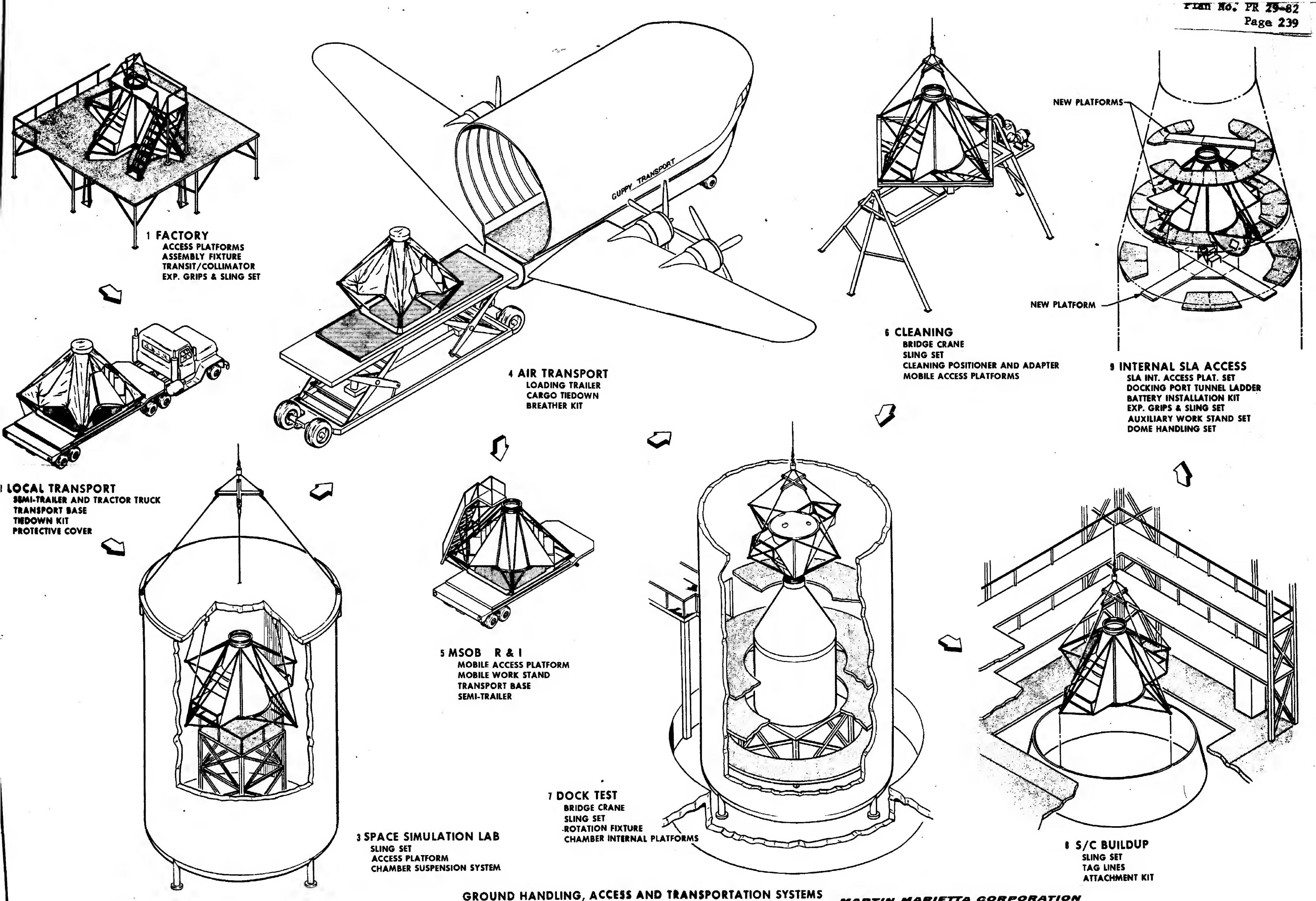
Existing TM ground stations at both Denver and KSC will be utilized for PCM and FM real time data and off line data collection, reduction and analysis. Although these ground stations will not be identical, they will perform in essentially the same manner. For KSC, the desired equipment is the Gemini PCM Ground Station located at the Hypergol 2 Building with the addition of the Signal Conditioner-Patch Panel. This addition is required to distribute the FM, timing, recorder playback and PCM data to displays and recorders. In addition, some interconnection changes will be required. The system should contain an adequate number of event and analog data displays and strip chart recorders. For Denver, a new ground station is currently being installed as an Air Force item within the Titan Vertical Test Facility. This station, with some similar minor interface modification, can support the AAP-1A system test requirements.

8.4.3 Ground Handling, Access and Transportation - An evaluation was performed to identify the handling, access and transportation requirements associated with AAP-1A carrier Denver and KSC operations. The objectives of this evaluation were to: (1) Provide a baseline configuration for AAP-1A carrier handling access and transportation, (2) identify items in these categories which could have a major impact on cost and/or schedule, and (3) provide the data necessary to scope the Phase D Engineering and Manufacturing effort.

Using the Denver and KSC ground operations flow as spelled out in PR 29-26, Flight Article and GSE Acceptance, and PR 29-27, KSC Ground Operations, as a baseline, a handling, access and transportation sequence was developed. A pictorial summary of this sequence is shown in Figure 8.4-3.

From this sequence, individual requirements were derived, technical approaches to meet these requirements were conceived, trade offs between candidate approaches were conducted, and finally, GSE end items capable of meeting individual requirements were identified (Refer to Table 8.4-I).

Data sheets were developed to present that data necessary for cost analysis and existing equipment survey. These data sheets include a description of the item, quantity, function, usage stations,



GROUND HANDLING, ACCESS AND TRANSPORTATION SYSTEMS
FIGURE 8.4-3

MARTIN MARIETTA CORPORATION
DENVER DIVISION

Table 8.4-I GSE End Item List

End Item Number	End Item Name	Quantity Required	Existing Equipment	Exist Equip Modified	Exist Design New Build	Mod Design New Build	New Design New Build
	SERVICING GSE						
293101	Service Set, Coolant	1					X
293102	Service Unit, Liquid Nitrogen	1					X
293103	Mass Spectrometer Leak Tester	1			X		
293104	Service Unit, Vacuum	1			X		
293105	Supply Unit, Freon	1			X		
293106	Air Conditioner - SLA	1					X
293107	Umbilical Set - Carrier	1					X
293109	Calibration Set, Black Body - Experiment	1					X
293110	Leak Check Unit	1					X
293111	Distribution System, Freon	1					X
	CHECKOUT GSE						
293203	Adapter Set - DTS to Experiments	1					X
293204	Power Supply and Distribution - Ground Checkout System	1					X
293207	Antenna Hat and RF Load Set	1					X
293208	Ground Display and Control Panel	1					X
293209	Battery Load Test Set	1					X
293211	Simulator, CSM	1				X	
293215	Experiment Peculiar Checkout GSE	1					X
293216	Common Experiment GSE	1					X
293223	Telemetry Receiver, VHF/USB	1					X
293224	Recorder, Tape	1			X		
293225	Limited Decommutation Station	1	X				
293226	Diode Tester	1					X
293227	Interconnections Set	1					X
293228	Systems Test Equipment	1					
(GFP)	Test Set, Digital (and 160G Computer)	1	X				
(GFP)	Ground Instrumentation System	1	X				
(GFP)	Ground Telemetry Station (Den and KSC)	2	X				
(GFP)	Console Modification	1					X
	HANDLING, ACCESS & TRANSPORTATION GSE						
293301	Work Stand, Mobile	1					X
203302	Base, Carrier Transport	2					X
293303	Installation Kit, Battery	1					X
293304	Platform Truck	1			X		
293306	Support Base - West Altitude Chamber	1					X
293307	Hoisting Tray, Parts and Equipment	1			X		
293308	Handling Set, IVA Trainer	1					X
293309	Cover, Protective, Carrier	2					X
293310	Sling Set, Carrier	1					X
293311	Platform Set, External Access	1					X
293312	Internal Platform and Ladder Set, Carrier	1					X
293313	Platform Set, Internal Access - SLA	1				X	

Table 8.4-I GSE End Item List (Continued)

End Item Number	End Item Name	Quantity Required	Existing Equipment	Exist Equip Modified	Exist Design New Build	Mod Design New Build	New Design New Build
	HANDLING, ACCESS & TRANSPORTATION GSE (continued)						
293314	Base, Carrier Support	2					X
293318	Portable Platform Set - West Altitude Chamber	1					X
293319	Sling Set, Experiment	1					X
293320	Work Stand Set, Auxiliary	1					X
293327	Alignment Kit, Optical - Experiment	1					X
293328	Rotation Fixture	1					X
293329	Breather Kit	1					X
293330	Dome Handling Set	1					X
293331	Attachment Kit	1					X
293332	Cleaning Positioner Adapter	1					X
(GFP)	B377PG Transport Kit	1	X				
(GFP)	Cleaning Positioner	1	X				
(GFP)	Hydra-Set (5-ton)	1	X				
(GFP)	Access Platform (FSN 1730-390-5620)	1	X				
(GFP)	Access Platform (FSN 1730-390-5618)	1	X				
(GFP)	Trailer, Loading (NASA CLT-45)	2	X				

Stimuli will be provided at both component and system level. The resultant output will be evaluated for adherence to specified tolerances.

A limited decommutator will be provided to synchronize with the PCM pulse train. A "hard wire" connection will be provided from the airborne encoder output to the limited decommutator to eliminate the necessity for open loop radiation during subsystem testing.

The majority of experiment GSE will be provided by the experiment manufacturer and where necessary utilized during systems tests. All electrical stimuli and status monitor interface requirements presently defined can be satisfied by the DTS.

As the G & N system becomes further defined, checkout requirements will be determined and integrated into the overall checkout approach. The local vertical sensing system checkout will be performed by the DTS.

8.4.3 (Cont'd)

criticality category, design category, lead time and probable source. The logic matrix and data sheets are presented in PR 29-40, Handling, Access and Transportation Evaluation. The equipment selection process made maximum utilization of existing Apollo line GSE.

The significant areas requiring ground handling and transportation are:

(1) Support movement of the carrier between the Spacecraft Assembly and Test Facility (SATF), and the Space Simulation Laboratory (SSL), from the KSC skidstrip to the MSO Building and from the MSO Building to LC34.

(2) Facilitate access to the integrated carrier during subsystem and system tests in the SATF, SSL, MSO Building, PIB and LC34.

(3) Facilitate site and flight article ground support during structural test, compliance tests; subassembly and experiments installation.

(4) Support weight and balance determination.

(5) Facilitate carrier station to horizontal and inverted attitudes

(6) Support cleaning operations, and

(7) Support Denver pack and ship activities.

Combined SLA/1A carrier access is needed: (1) during the fit check in the MSO Building (East Integration Stand), (2) when the carrier and SLA are mated for spacecraft buildup, and (3) during launch complex test and service operations. These requirements can be met by incorporating the following modifications into the NAA SLA internal platform set:

- Add criss-cross platform at level X_a 525 to provide access to lower dome assembly.
- Add side access platform at level X_a 130 to provide access to batteries, and external mounted experiments such as S017 and S040.

8.4.3 (Cont'd)

- Add a short catwalk at level X_a 697 to provide access to the Docking Ring for entering into the 1A tunnel.

- Provide a dome removal kit.

- Provide an auxiliary stand to allow access into the 1A carrier tunnel from the dome end with the dome removed.

SLA internal access to the 1A carrier can be provided by using a basic LM, NAA furnished, platform set with modifications and additions as defined in this report. New provisioning of a set, basic to the 1A carrier, requires a high initial procurement cost of approximately $250,000. It is recommended that joint usage of one of the existing LM sets be implemented since it would entail only a $50,000 modification cost. Analysis is required of the Apollo real time schedule in order to ascertain that joint usage is feasible.

The existing KSC cleaning positioner already in joint usage should be equipped with a 1A carrier adapter to allow rotation of the carrier with the trusses attached.

The majority of the remaining GSE items such as the experiments alignment set, carrier sling set, subsystems handling set, and carrier support base, are peculiar 1A carrier new build items. These are not long lead or high cost items. An experiments peculiar grips and sling set will be required for Denver and KSC handling and installation of experiment components. In some cases, this equipment is available and will be provided by the experiment contractor. The frog otolith installation may require additional special handling and access equipment and countdown procedure control. In general these requirements can be met by an approach completely compatible with normal Apollo operations.

8.4.4 GSE End Item Summary - The analyses and trade-offs made during the study resulted in the selection of a baseline set of servicing, checkout, and handling/transportation GSE. This baseline list is presented in Table 8.4-I. Identifying numbers have been assigned with the 2931XX series used for servicing equipment, 2932XX series for checkout equipment, and 2933XX series for handling, access, and transportation equipment.

8.4.4 (Cont'd)

After the baseline equipment was selected, a GSE Requirements Data Sheet was prepared for each item. In addition to end item name and number, each sheet defines quantity, function performed, usage stations, criticality category, description of equipment, modification definition, estimated lead time and probable source. This information has been summarized on GSE Data Summary Sheets in PR 29-39, Ground Checkout System, PR 29-40, Handling, Access and Transportation Evaluation, and PR 29-22, Ground Servicing Systems.

8.5 Conclusions and Recommendations - Significant conclusions and recommendations are:

- There are no ground operations or GSE requirements which are incompatible with a January or February '69 AAP-1A launch. However, a January launch would require reducing the normal 4 month KSC operation to 3 months, which in turn would require approximately 50 days of two-shift operation.

- Considerable amount of GSE from the mainline Apollo program can be utilized to meet AAP-1A requirements. It is recommended that analysis be continued to determine availability by serial number of usable surplus equipment.

- The majority of GSE items are quantity one each for use at both Denver and KSC.

- The basic LEM internal SLA access set can be modified to meet AAP-1A pad access requirements without destroying the LEM capability. It is recommended that one of two existing LEM sets be provided on a joint usage basis. Further investigation of Apollo real time schedules must be performed to establish feasibility of this approach.

- Automatic checkout at Denver and KSC using the existing DTS will enhance the capability to meet AAP-1A accelerated program schedule. It is recommended that the existing DTS set (with computer) be provided to this program as GFP.

- The Denver VTF TM Ground Station and the existing Gemini Ground Station in Hypergolic Bldg. #2 at KSC will meet KSC AAP-1A requirements with minor interface modifications. It is recommended that the KSC Gemini Ground Station G/S be provided as GFP for this program.